SILICON CHIP

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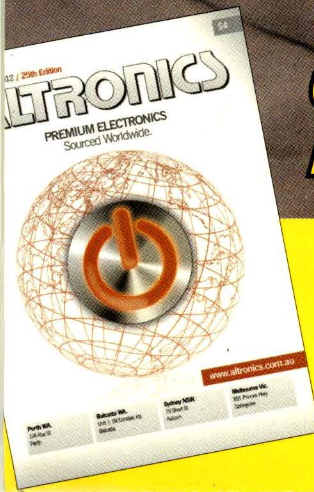

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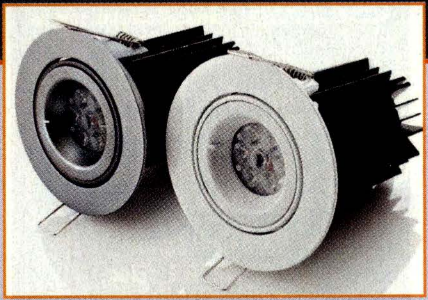

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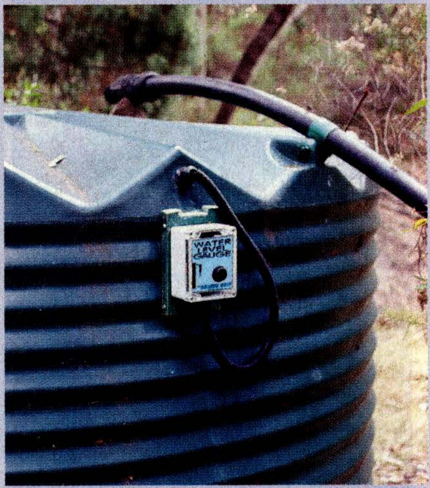

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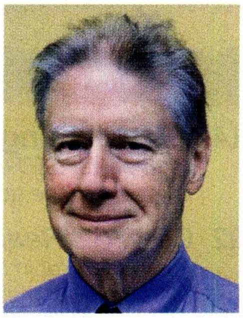
Publisher's Letter

Rising electricity tariffs causing hardship to people on low incomes



Ausgrid, which provides power to much of the state of New South Wales, has announced that demand for electricity by regular households has fallen 2% each year for the past four years. Ausgrid says the drop is caused by consumers switching to energy-efficient hot water systems and light bulbs after seeing their power bills go through the roof.

"One example where we have seen most strongly is with residential hot water because we often separately meter this in households," Ausgrid energy efficiency specialist Paul Myors said. "We've seen reductions even greater than 2%, even up to 8% per year," he said.

Well, surprise, surprise! It is typical that a state-owned energy retailer would attempt to put a positive spin on the story by saying that the reduction in demand is caused because people are going to energy-efficient hot water systems and light bulbs. That is not the whole story; far from it. Yes, people are going over to solar, heat pump and gas hot water systems but this is in response to heavy promotion and generous state subsidies.

Add to that the rush, by those who can afford it, to take advantage of the even more generous state subsidies and grid feed-in tariffs for roof-mounted solar systems. Several states have now seen the light and cut back and then abolished these grid feed-in tariffs because they were far too generous. In fact, by the time that all the subsidies to domestic solar electricity have been paid out, New South Wales could probably have built a full size coal-fired base-load power station.

But the big reason why people are cutting back is simply that tariffs have risen so much. In four years they have risen by over 60% and similarly steep rises over the next few years are expected. For most people this will be shrugged off as yet another symptom of rising inflation but those on low and fixed incomes are taking a more drastic approach – they are not heating their homes in winter.

For anyone who is fit, healthy and able to move about briskly, this is probably not a great hardship but for older people it amounts to a significant reduction in quality of life. Think about it. Say you are frail, suffer from arthritis, rheumatism or osteoporosis (or all three together) and you are cold as well. This means that you are much more prone to falls, breaking bones and subsequent hospitalisation. Many people never fully recover from a bad breakage.

Many such people go to bed early and rise late, merely to stay warm. In effect, they are accelerating the onset of old age and subsequent lack of mobility by electing to go without reasonable warmth in their rooms.

Worse still, because it has been drummed into them about how much power is used by lighting, such people are not turning on room lights – after all, they use heaps of power, don't they? Moving about in semi-darkness further increases the risk of falls and injuries. This is happening in Australia – one of the richest countries in the world! How have we come to this?

If you think I am exaggerating this problem, consider the runaway sales of products like "Snuggies" which are essentially wearable blankets. Large numbers of people are using these in preference to room heating. Again, ultimately this is a decision to reduce overall quality of life, fitness and longevity. People should be able to enjoy reasonable comfort, in winter and summer, without feeling guilty or having to "go without" some other essential.

Much of this nonsense has been brought about by governments wanting to be seen to "be doing something" about climate change. Well it is having very bad unforeseen consequences for a significant proportion of older people and it will actually mean a greater burden on the public health system.

Governments need to look at this as a matter of urgency. They have tried too hard to change peoples' behaviour and it is having entirely the wrong effect.

Leo Simpson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Sceptical of merits of extreme low distortion

I have just read the Publishers Letter on the quest for ultra-low distortion in the July 2011 edition of SILICON CHIP.

While I can understand the thrill of the technical chase in getting the distortion down, I wonder at the practicality of .0006% distortion. Would I actually hear the difference or would I need an anechoic chamber and the latest distortion measuring doo-hicky to know what the distortion is?

While you may think that iPods offer mediocre performance, I and millions of others think that they are great.

Peter Williamson,
Wollongong, NSW.

Comment: .0006% total harmonic distortion is extremely low but we have little doubt that if we set up "double-blind" listening tests, most people would be able to detect the subtle differences between our Ultra-LD Mk.3 amplifier and other amplifiers with lesser performance (provided their ears had not been damaged by listening at high levels to MP3 players).

It is very significant that our Class-A amplifier has such a well-deserved reputation for very clean sound. Our latest Ultra-LD Mk.3 design is very close to the Class-A's performance but has the big advantage of delivering a lot more power.

As to your comment about iPods "being great" we can only say "compared to what?" The fact is that "millions of others" simply don't know any better.

CD-ROM drives can make powerful motors

With respect to the question raised by B. L. on CD-ROM drive motors (Ask SILICON CHIP, July 2011, page 98) the following may be of interest.

The conversion of CD motors by rewinding them and most importantly by fitting "super" NdFeB (neodymium iron boron) magnets was pioneered by German enthusiasts and has long since become world-wide. They are capable of powering worthwhile models.

The brushless motors used in model aircraft are amazing. Their power-to-weight ratios are better than their IC equivalents in many cases and they can be monsters; the biggest I know of is 15kW and weighs less than 2kg.

CD motors are a good source of small motor stators; larger ones can utilise armature laminations from a dead motor such as an electric drill.

The controllers are readily available from model aircraft shops but kits and DIY data is scarce. The only one I know of was in the February 2006 issue of Elektor magazine.

To obtain information on magnets for motors, just Google "supermagnetman" and select "motor magnets".

Arthur Davies,
Ainslie, ACT.

First-hand experience with converting CD-ROM motors

I have just read the response in Ask SILICON CHIP in the July 2011 about converting an old CD-ROM motor for model aeroplane use as well as circuits for brushless controllers. The answer is not correct and the whole area is an accepted modeller's DIY discipline and covered reasonably well on the web (though you have to know where to look for such articles).

The fact is one can make a very powerful brushless motor on a par with or even more powerful than what can be sourced commercially. The answer to the question also talks about brushless motor controllers and is quite negative,

Praise for the Maximite

The Maximite (SILICON CHIP, March, April, May 2011) is a great project and hits the spot like no other project for quite some time, in my view at least. There are so many purposes we may have for this little gem, rekindling the fire of the 70s and 80s when tens of thousands got into microcomputers based on Z80s. It really was a great era of discovery.

Whilst I'm still enthusiastic to see BASIC running on modern platforms, I recall that much of the success of Microbees, TRS80s, Commodore 64s, etc were the applications in the form of software and firmware which gave you mainframe and machine functionality at a rock-bottom price. A word processor is not a big deal any more but the short program required to store and feed a text file or a graphics screen dump to a PC for a print-out would be a great asset for such a small device.

Just consider the size and cost of a Maximite with PSU, flexi-keyboard and 7-inch or cheaper, larger screen compared to a netbook, dinky keyboard and proprietary software, with their limits to usefulness. This is the way to go for experimenters and tinkerers!

So I would like to see the development of BASIC software to puff up the appeal of the Maximite even further, otherwise we will find over time that interest wanes when our best efforts are just not good enough to write truly useful programs. Perhaps the author of MMBasic would be prepared to venture into a simple office suite like a WP/spreadsheet/graphics, even based on old and lapsed copyrights. Is it not worth a try, perhaps even sponsoring others who are game enough to do something more engaging than timing taps and data-logging?

I'm sure this or similar serious application software will keep the project alive and a constant stream of serious input being tendered for publication.

Ian Finch,
Urunga, NSW.

however there are several excellent and relatively simple designs using readily available "analog" electronic components (as well as PICAXE-type stuff) on the web for those interested.

As an avid aero-modeller and experimenter, I have made dozens of these motors from dead CD-ROM drives sourced through my computer repair company. These motors are absolutely brilliant and very usable. In fact, some of the commercial motors purchased from Chinese manufacturers have the exact same chassis as a CD-ROM motor-based unit, proving their suitability for the job.

For the avid DIY modeller, there is no need to invest in expensive motors and brushless controllers when they are easily built using everyday parts. The only hard-to-source part needed, and even then these are not that difficult to find with many people on the web selling them (including me if I am asked), are the required neodymium rare-earth magnets (reasonably cheap at about $7.00 per dozen and 12 are required per motor).

All one has to do is source the right-sized motor (about 40% of CD and DVD drives use them), carefully disassemble it and remove the existing graphite magnet ring, add the rare-earth magnets (straight or curved), strip and rewind the stator with heavier-gauge wire and connect it to a controller, self-made or commercial. Add a LiPO battery and away it goes, ready to mount in a model.

Dave Thompson, PC Anytime Ltd, Christchurch, NZ.

Obsession with low harmonic distortion

I would like to ask if SILICON CHIP has become besotted with getting harmonic distortion to an all-time low, and forgetting to listen to the music. What about the speaker system with variable phase distortions etc from crossover networks and the like. I am sure the 0.004% of the Ultra-LD Mk.2 would go unnoticed.

I remember building a nice little amplifier from ETI and apart from replacing the TIP transistors with more rugged BDV64 & 65 transistors, it remains performing well to this day. The highlight of the article was low intermodulation distortion.

I note that no IM checks seem to get done on these amplifiers. Personally, I would rather the IM was low as I have attended live performances and had to shiver from the IM distortion produced by some PA systems.

Bill Bool, Perth, WA.

Comment: some readers probably do think we have become obsessed with ultra-low harmonic distortion and it is fair to wonder how such low distortion would be of any benefit when distortion in the recording chain and the loudspeakers is obviously much higher. However, the distortion and non-linearities in loudspeakers do not mask the distortion in amplifiers. Partly this is because amplifier distortion contains higher order harmonics.

The proof is in the listening. Amplifiers such as our 20W Class-A and Ultra-LD Mk.3 simply sound much cleaner than other amplifiers. CDs which may sound harsh on one system (particularly with sopranos and tenors in solos or with choral performances) just sound natural. It can be quite a revelation. Similarly, feeding a signal direct from a CD player to a power amplifier can sound better than if it goes via a preamplifier or control unit.

It is true that we don't publish IM figures and the reason is that if THD is very low, IM is also very low; both are measures of non-linearity. Of course there are several ways of measuring IM and the old 7kHz/60Hz method is not particularly revealing. A better is test involves using two high frequencies such as 18kHz/19kHz.

We would be surprised if any ETI amplifier had low intermodulation since few of their designs had particularly low THD.

ETI magazines to give away

I have a large number of ETI magazines to give away as I am down-sizing

New Altronics Store To Open In Balcatta, WA

Altronics are opening a fourth One Stop Electronics Shop in the suburb of Balcatta, Western Australia. According to the company, the new store represents the culmination of Altronics' recent expansion in the west, having shifted their warehousing operations to Balcatta and expanding the Roe Street retail store and production floor.

The new store, located at Unit 7, 58 Erindale Rd, Balcatta will offer the full Altronics range, with a strong focus on trade customers. Its location is ideal for northern suburbs customers, being only a short drive from Joondalup, Morley and coastal suburbs. It will also feature a sound lounge for audio demonstrations, allowing customers to try out speakers and audio gear before buying.

The grand opening will be on September 12th and the store will be open for business from 8am to 5.30pm Monday to Friday and from 8.30am to 5.00pm Saturday.

Digital radio – the future or just a pipe-dream?

A recent ChannelNews web report stated: "As Commercial Radio Australia lobbies the Federal Government for millions of dollars in funding, new research shows more people in the UK are buying analog radios – (they) prefer to stick to FM radio".

UK communications regulator Ofcom said that with millions continuing to buy traditional sets, the "aspirational" target of 2015 to move all major stations off FM and AM and on to digital looks unlikely. Only 1.9 million digital radios were sold in the year to the end of March 2011. This compares with 6.6 million analog sets. The report also found that less than 1% of vehicles are fitted with a DAB (Digital Audio Broadcasting) radio.

Commercial Radio Australia is claiming that over 500,000 digital radios have been sold since the service was launched two years ago.

Note the 2015 target to remove all major AM and FM stations to digital. Is this planned for Australia and if so, why is it not public knowledge? Do we need to start lobbying the Government, so about 60 million Australian receivers (including those in cars) are not made obsolete?

Digital radio, like digital TV was hailed as a major leap forward. Most would agree digital TV is clearer, with many more channels. I even have two PVRs and a DTV working to a very high standard on rabbit's ears – until I get time to get into the second-storey roof and install a quality antenna. There's no rush on that one though as the viewing is excellent.

But can the same be said for digital radio? We were told that listening would be far superior and car stereos would be free of interference. Nothing could be further from the truth and few solutions are appearing. Only receivers like the SILICON CHIP DAB+ radio project fully realise digital quality.

Yet for everyday use, digital radio has dipped into our taxpayer's money with little result. An associate has a DAB+ portable radio and listens to his AM/FM receiver more. Why? Portable DAB+ receivers with almost no exceptions are expensive and can only be heard in mono from an atrocious tiny speaker.

Then there are the reception problems. You can listen to AM radio station 3AW right into Gippsland (country Victoria) but not DAB+. 3AW AM consistently wins the ratings.

What do SILICON CHIP readers think?

Kevin Poulter,
Dingley, Vic.

More magazines to give away

I have a quantity of electronics magazines to give away. Somebody who may have lost everything in the fires or floods may like to have them and it would be better than putting them in my recycle bin. I don't know what the freight would be from Tasmania.

The magazines I have are: (1) Electronics Today International (ETI) from January 1978 to April 1988, (2) Electronics Australia (EA) from December 1973 to April 2000 and (3) SILICON CHIP from November 1987 to December 1999.

Michael Neep,
Phone (03) 6340 1466.

(Preceding letter continued:) my home. The issues range from 1975-1988 with only an odd missing issue. Rather than go to recycling, I'd rather someone take them off my hands at no cost to me.

Colin Christensen,
Redcliffe, Qld.
Phone (07) 3284 7783.

There's an App for that...

I have just seen the August 2011 issue. An electronic stethoscope? There's an app for that. A digital spirit level? There's an app for that too. It's bizarre. You are coming up with projects to build things that are made out of parts that are cheap these days because they are in the smart phone that most of your readers already have in their pockets. It just needs software.

The people who tell us that the NBN (at least an NBN in the form of an ultra-high speed fixed line to every home) will change everything are too last century in their thinking to understand. The smart phone in their pocket that has all those sensors – GPS for position, a good microphone, a camera, accelerometers, gyroscopes, a fast connection to everyone else, all the data on the internet, and the storage capability of the cloud – is what's going to change things. It's just a matter of using them.

Gordon Drennan,
Burton, SA.

Comment: thanks for bringing those applications them to our attention. We should point out though, that while the stethoscope application does have fancy graphics, it actually requires an electronic stethoscope. Funny that.

We spoke about the spirit level application to the designer of the Digital Spirit Level, Andrew Levido. His response was fairly tart in that he didn't fancy using his iPhone to check levels when he was laying bricks! In any case, those applications don't have the precision readings of our project.

3D printing not so new

Your article on page 90 of the August 2011 edition about 3D chocolate printing is a little outdated where it goes on to say that researchers from Cornell University in 2010 were using liquefied food as a printing ink.

For a number of years, bakeries in Australia have been using a commercial system that uses a standard Canon multi-printer to scan and then print customers' images on to rice paper, using vegetable dyes in place of the normal inks. The rice paper is then placed on top of a cake, where the moisture from the cream or icing dissolves the paper, leaving the image.

A number of companies also produce images of popular cartoon items on rice paper using flavoured edible inks, to be placed on cakes. There is nothing new under the sun.

John Arnfield, VK4JR,
Narangba, Qld.

Comment: yes but now there is the possibility that those same bakeries

Another application for the Inclinometer project?

I read with interest Andrew Levido's project for a Digital Spirit Level based on a MEMS accelerometer chip (SILICON CHIP, August 2011).

I pondered whether it would be possible to use this project as an "angle of bank" indicator while flying my glider (sail-plane). However, after reading the description of how the MEMS technology works, I am unsure if it is plausible to use this device in a situation where it is subject to constant movement and also exposed to differing environmental forces than those experienced in a stationary situation. For example, the centrifugal forces felt when banked over, flying in a circle.

Andrew's mention of nano-scale mechanical devices within the chip and the need to compare the forces these experience in relation to gravity makes me think it is probably not possible to use it in this application. But on the other hand, DSPs and crafty software engineers can do amazing things these days so I thought it worth asking you before dismissing the idea.

Pete Mundy,
Nelson, NZ.

Comment: that is a very interesting question which we were only discussing with the designer recently in relation to a related project – an accelerometer for cars.

It turns out that if you are to take into account gradient of hills and banking of corners, the single MEMS accelerometer chip cannot do it. Instead, its readings have to be adjusted with reference to a MEMS gyroscope IC. It is certainly not achievable by the August 2011 project itself.

That said, there is a possibility we may do an enhanced version in the future.

could produce 3D decorations in icing or chocolate. Sounds tasty to us.

Calibrating the Capacitance Adaptor for DMMs

I purchased the kit for the Low Capacitance Adaptor for DMMs (SILICON CHIP, March 2010) some weeks ago. The sockets supplied with the kit were of the very cheap variety which I replaced with the gold-plated machined pin variety. When assembled, all the waveforms and voltages appeared to be OK. The null adjustment was 0.7mV which was OK.

Unfortunately, when it came to calibration time, all was not well. With VR1-VR3 set to minimum values I wasn't quite making it with the calibration voltages. After further thought, it seemed to me that the 10kΩ resistor connected to IC1a pin 2 and IC1b pin 3 was a little bit on the high side in value.

The PCBs supplied with kits often cannot be repeatedly resoldered without lifting the tracks so I carefully lifted the resistor and installed two 1mm matrix pins to enable me to try some resistor values. As it happened, I worked out that an 8.2kΩ metal film resistor would do the job.

After installing it, I switched the unit back on, adjusted the three 20-turn trimpots and all the adjustments fell into place.

Glen King,
Elizabeth East, SA.

Vintage radio measurements are not simple

In the March 2011 issue, Robert Bennett from New Zealand wrote a very interesting letter on 4-valve receivers. Robert would like to see sensitivity and distortion figures for these old receivers and in an ideal world, I'd like to be able to provide them.

If the receivers were designed for 50-ohm or 75-ohm resistive input like most communications receivers are, this would not be difficult. However, domestic receivers are (or were) designed to work into antennas that are quite short with regard to the frequencies received. The antennas have quite complex capacitive and/

Dissatisfaction with PVRs

I recently purchased a new hard drive recorder and a new HD set-top box. The set-top box, which only cost about $70.00, has the added feature of being able to record to a USB drive via the program guide which is very useful. However, I found that the antenna loop was only active on both when the appliance was switched on.

This meant that when just wanting to watch TV, the recorder or set-top box also had to be on (they are in different rooms). As a result, I had to take the hard drive out of the loop because unless it was on, none of the TVs in the house worked.

I have my Foxtel, hard drive recorder and DVD recorder/player in the antenna loop which then goes to a splitter and then to five TV sets in different rooms. In the old days my VHS recorder fed an RF signal back into the loop, on channel 0 or 1, so it could be watched in every room but modern recorders do not have this feature.

My Foxtel still has this feature and can be watched on all TVs, however as it is an analog signal it can't be received by the hard drive recorder and so I can't record Foxtel on it.

My gripe is why is the antenna loop not active all the time and why have manufacturers stopped including an RF modulator to re-send the signal into the loop? I know I can use an RF sender but it is a nuisance to have to switch on and then switch either the hard drive or DVD to it. It seems to me the manufacturers have to get some standard going.

Paul Cahill,
Rooty Hill, NSW.

or inductive reactances as well as a resistive component and this varies across the broadcast band and also the shortwave bands. Receiver manufacturers endeavour to match these complex reactances and resistances on the broadcast band but rarely do so on shortwave.

Whatever they do must be a compromise and measuring the input sensitivity would mean building a complex network to attach to the antenna/earth terminals of the set. No serviceman would be bothered doing this.

A number of years ago I was involved with the testing of 500kHz marine auto-alarm receivers to international regulatory standards. I did use a specific complex network to test their sensitivity but this was done on one frequency, not a wide range of frequencies as for the AM broadcast band.

The distortion figures for a standard vintage radio can be in the region of 5-10%; grossly inferior to the many high-quality amplifiers available today. My attitude is if it has a pleasant sound, then the receiver is working as it should. If it sounds edgy or distorted at any signal strength or volume setting other than at very high volume, I will investigate it, usually with an oscilloscope.

Robert believes I am wrong when I say that AGC could have easily been provided on the Astor DL described in October 2010. AGC could have been applied quite simply and some points that Robert has made about the application would be true. He is quite right that applying full AGC to a small set like this with limited audio gain may reduce the maximum audio output, however some sets can accept full AGC without limiting the audio output. It has a lot to do with set design.

In this set, AGC at an appropriate level applied to the converter stage would have worked well. Applying AGC to the IF amplifier would also have worked and its application would reduce the gain of the IF stage and the effect of positive feedback. AGC is designed to reduce the gain of the RF section of the set and help maintain a reasonably level audio output.

And while all that I have said about manufacturers not fitting AGC to simple sets is true, there was another reason: patents. Receiver manufacturers had to pay a royalty for almost any circuitry that was used in the receiver, of which AGC was one. Hence, manufacturers endeavoured to get around various patents so that they could keep the price of their sets down.

Referring now to the Philco 40-40 in the December 2010 issue. I agree the circuit shown is not wonderful, but that is how it was presented in

Mailbag: continued

Wanted: a good DIY loudspeaker system

Over many years I've been reading about and building audio amplifiers it's been fairly rare that a discussion has taken place on what speakers should be paired up with a particular audio power amplifier.

In years gone by I've usually purchased Philips, Baker, Wharfedale or Goodmans and was usually satisfied with the result. When I built my set of Philips enclosures with a 12-inch woofer, mid-range and tweeter I received from Philips an enormous amount of information with all you could desire as well as construction information, all on art paper.

After all, it's going to be the loudspeaker that is going to make a difference as to how an amplifier could sound. With the Ultra-LD Mk.3 your staff did go to quite a lot of effort to create it. As you are aware there are many Asian-made speakers around now that are made from all kinds of materials and have all kinds of characteristics despite what is written in the local catalog.

Of course one can go off and buy a set of Vifa speakers or similar speakers, provided one can afford them. It can be difficult to try before you buy – it seems these days one almost purchases loudspeakers on faith alone despite all the technical detail.

I've purchased several technical books on speakers but most of them only cover certain aspects on speakers, mainly the smaller enclosures. Most of the principles are there in the books but there are several aspects missing. There is nothing, for example, on electronic crossover networks. The best site I've been able to come up on this is **www.sound.westhost.com**

Speaker enclosures have also changed shape too – many of them are narrower, a bit taller and sometimes deeper. I think you mentioned in one of your articles that there was an amazing amount of rubbish about; I agree. Whenever I go into a store I find that the bass has been turned up too far and the effect is unnatural.

Glen King,
Elizabeth East, SA.

my library of circuits. Robert believes that the second IF has both windings tuned by the one slug. Whilst probably correct up to a point, the secondary is not tuned, however its inductance is changed because of its close proximity to the tuned winding.

Rodney Champness,
Mooroopna, Vic.

Installation of solar panels is potentially dangerous

I recently decided to install a grid-connected PV system on the roof of my home and office in Toowoomba. The offer was for 10 x 190W monocrystalline panels with a 2kW inverter for a total installed price of only $4000, after Small Technology Certificates are deducted.

Two installers screwed brackets to the roof battens and fed wires through the tiles whilst a third man installed the inverter and DC isolator switch in my storeroom which shares a common wall with my meter box. I wanted them mounted there so that they would be out of the weather and tamper proof. The cable used to connect from the isolator switch to the panels was just twin black, with no indication of which wire was positive or negative.

I also wanted all of the panels properly earthed. The two supervising electricians who followed up on this work have refused to do this earthing for me. I was asked to sign off on the installation without earthing. I refused.

I went to Ergon who advised me to go to the Office of Electrical Safety. Another local solar supplier/installer advised me to look at the website of the Clean Energy Council at **www.cleanenergycouncil.org.au** and also the Australian Solar Energy Society site at **www.auses.org.au**

My initial concern was to give lightning an easy path to earth, so as to protect my tile roof and home from burning down in the event of a direct hit during a thunderstorm. Those two websites explained why earthing is now considered necessary everywhere, including Queensland.

The papers that I referred to were:
(1) Australian Solar Energy Society Issue 01, April 2011. Tech Advisor – Solar Best Practice: pp. 1, 2 Module Frame Bonding to Earth; p3 DC Isolator Ratings.
(2) Clean Energy Council – Tech Info, Feb 2010 Documentation . . . Grid Connected PV Systems; Tech Info, Oct 2010 PV Isolation Voltage Ratings and Wiring; Tech Info, Nov. 2010 Earthing PV Module Frame.

The other reason for earthing is that some inverters can cause leakage to occur and can make the frame of the solar panels live. It was in Queensland that a child received an electric shock from a ladder that was touching a roof where his father was cleaning some panels.

The Clean Energy Council has decided that all transformer-less systems should be earthed for protection. There are so many different brands and models of inverters and panels on the market that they don't have the resources to test them all. So earthing is required for all models.

The other major issue, was the correct installation of the DC Isolator Switch and its voltage rating. The isolator installed here is rated at 500V DC. It should be rated at around 1100V DC.

Critically important is both polarity and direction of current flow. To quench the arc created when the switch is opened during the day when sunlight is generating electricity, a magnetic section is built into the isolator switch. It will only work, if wired so that current flows in the correct direction.

I phoned the office of the company and spoke to the manager who said I should be paying extra money for earthing.

I told him that I intended to visit the Office of Electrical Safety and that if he didn't fix these problems at his expense, I would be going to the Office of Fair Trading. He asked me to send a fax with the work I required to be done.

I visited the Office of Electricity Safety in Toowoomba. I met the Principal Electrical Safety Inspector and another man. They listened to my story. They visited my premises and took photos of the PV panels, the inverter and meter box/switchboard.

They had two concerns:
(1) Is the earthing set down in the Australian Standards? If not, too bad for me.
(2) Is the inverter of the type described in the technical information from the Clean Energy Council? If not, then again too bad for me.

I tried to explain that none of these inverters have an isolation transformer. They acknowledged this fact but still wanted to distinguish my model from others, based upon the design and the risk of leakage. This is in contradiction to both the Clean Energy Council and the Australian Solar Energy Society.

In Queensland we no longer have any electrical inspectors attached to the state-owned distribution company, Ergon Energy. Instead we have "self inspection" by the very types of electricians that I am complaining of.

The Government advertises to us on TV "Who Are You Keeping Safe?", putting the responsibility for electrical safety onto the shoulders of mothers.

I believe that further investigation is warranted, to determine how many other households have un-earthed, potentially dangerous, PV arrays installed on their roofs.

Chaim Lee,
Toowoomba, Qld.

FutureWave Energy Saver compliment

Congratulations to Ross Tester and the makers of Future Wave Energy Saver, as reviewed in the June 2011. They seem to have done a good job and really dug into the characteristics of induction motors to make something useful.

The way induction motors can be made to do clever things with variable frequency drive is not well understood, even by engineers, so the two "motor re-winders' in a shed on the Sunshine Coast are to be commended.

John Waller,
Plainfield, CT, USA.

Another way to reduce pump power consumption

The FutureWave Energy Saver (reviewed in the June 2011 issue) is a good invention but why not just buy a DC pool pump? Made by at least two large pool equipment manufacturers in Australia for around $800, they have a 3-speed switch and save at least 70% in power usage on low speed compared to an AC induction motor on fixed high speed.

I have installed VSDs (variable speeds drives) on AC motors before but have run shielded cable from the controller to the motor to cut down on EMI. This is normally stated in the instruction book supplied with the VSDs.

Geoff Bensley,
Byron Bay, NSW.

Comment: the article on power saving this month includes information on DC variable-speed pumps.

Add-ons for the Electronic Stethoscope

With regard to your Electronic Stethoscope in the August 2011 issue, for years now I have been using a 2-transistor circuit for the same sort of thing. The main difference is

that I mainly use a small coil or an old telephone pick-up (suction cup style). This is handy for sniffing around electronic circuits to see which parts are doing something or not.

You can hear oscillator, clocking, audio and switching noise fairly easily as long as there is not a large power transformer or supply close by. These tend to mask out most other electronic noises.

I have put an RCA and 3.5mm mono input jack socket on mine and have a variety of input devices to select from, eg, telephone pick-up, electret microphone, phototransistor or standard audio source. Some readers may like to experiment using electronic noise or light, eg, IR remote type signals as the input source.

Michael Jeffery,
Eurobin, Vic.

Did the projected energy savings eventuate?

It has been about a year since you featured the article "Slash your Factory Office Lighting Bill" (SILICON CHIP, May 2010) and changed standard fluoros to quad phosphor tubes. I wondered how your power bills were working out?

Norman McGeoch,
Hornsby, NSW.

Comment: that's a tricky question. Our last quarterly electricity bill (August 2011) for the SILICON CHIP offices showed that consumption was up by 2kWh a day compared to the

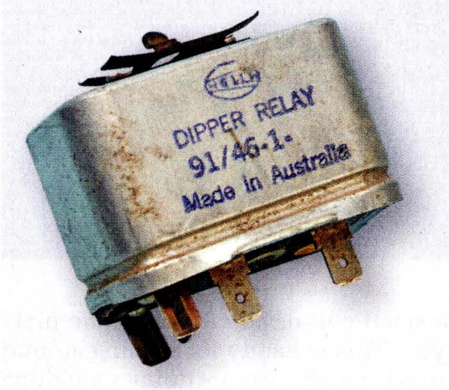
Looking outside the square

I read your June 2011 edition with interest but a couple of articles really intrigued me. They point to a narrowness of thought and experience.

When I plugged the hearing aids in, pulled on the cardigan, found where I left my glasses, staggered over to my crutches, remembered where the light switch is and eventually located the "collectables" bin in my workshop, I discovered, wonder of wonders, a dual state relay!

This beast, dating from the mid-1960s, is a device that I would think 80% plus of your readers use every day. It is a latching relay, otherwise known as the ubiquitous automotive headlight "dip switch".

These 1960s Hella/VW relays use an inverted heart-shaped internal cam that is flicked from one position to the other when the "dip switch" is pressed. As the armature pulls in, the cam is pushed to the other position and a spring holds the contacts in the new position.

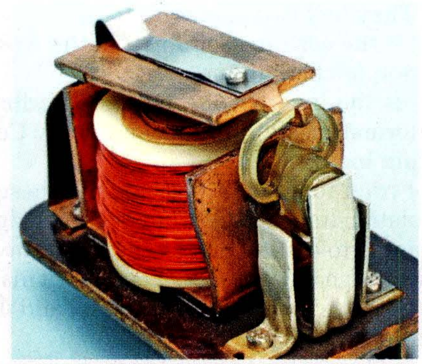


If you look carefully at the photo of the "cam end" of the relay, it is apparent that the armature is in one position. It moves to the alternate position when the dip switch is pressed.

So the latching relay used in your VersaTimer/Switch (page 62, June 2011) is not new.

Further, when I listen to my AM radio whilst reading the article on the FutureWave Energy Saver I realise that it is actually within three feet, through a brick wall, of the compressor unit of my air-conditioner and less than five feet from the internal head unit. The air-conditioner is an "inverter type" and it is noticeable that both the compressor motor and the fan motor vary their speed considerably. A quick look shows that the compressor motor is an induction type.

Ergo, the inverter is feeding the motor variable frequency AC. The interesting point is that there is zero AM interference and as a check, I



placed the radio on the compressor box and tuned the radio, to ABC 702; I live in Canberra. No interference! Tuning the radio "off station" produces white noise but that does not vary with distance from the unit nor does turning the unit on and off change anything.

Brian Wilson,
Curtin, ACT.

Comment: latching relays have certainly been available for many years although not readily available from electronics component suppliers. We are not sure whether they are presently common in cars.

As far as the AM interference from variable speed drives is concerned, we are well aware that it can be filtered out. That is why we noted that the interference was present.

same period last year. The previous quarterly bill was down by 1kWh a day compared to the same period last year.

We stated in the May 2010 article that the changes in overall power consumption would probably be small and these results demonstrate that. Making overall power consumption comparisons from period to period or year on year is a flaky operation at best since there are other variables.

You would have to ask questions like: was the aircon thermostat setting maintained at the same level over the comparison periods and were the outside ambient temperatures over the respective periods comparable?

In any case, any savings that we may have made due to more efficient lighting will be swamped by the higher electricity tariffs.

We think that if we are to make further savings in our energy consumption, the only way will be to install double-glazing (with low-E glass) in all the windows. That is an expensive proposition and the likely payback period is hard to quantify.

Strategy for dealing with dazzling headlights

With respect to the recent comments on this topic, I too have a problem with dazzling headlights coming towards me. I don't know if they're a problem in Australia but in North America you can buy super-bright lamps with a bluish tint, often sold as "Xenon" lamps, and they are a real problem for me (and many others).

I spoke to the RCMP (Royal Canadian Mounted Police) here in Canada about them a while ago and they mentioned that there are standards on how much light can be thrown by a vehicle headlamp. However, although many of these "Xenon" lamps are probably too bright, it's practically impossible to measure or police them.

I've found a simple solution though. I stick a small strip of transparent red-tinted acrylic, about 30 x 150mm, to the inside of my windshield to filter the headlights from on-coming vehicles. It's at about the horizon level from my seated position and right in the light path from on-coming vehicles.

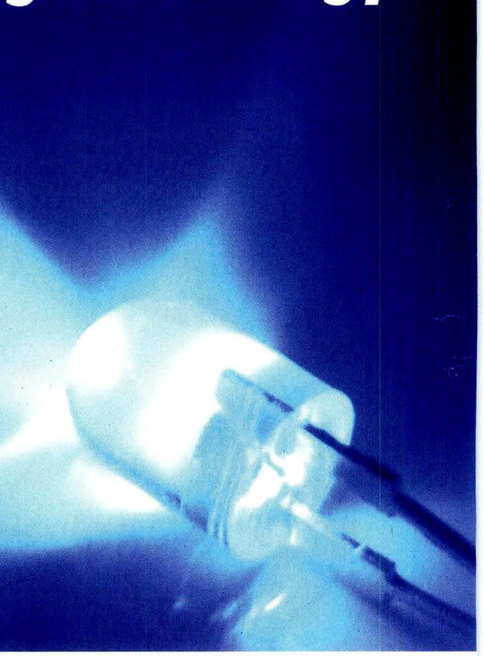
I stick it on with a bit of tack putty so I can remove it during the daytime. By tilting my head slightly as vehicles approach, I can keep most of the on-coming headlights in the strip, reducing my glare problem.

I don't know how legal something like this is but given that it's improving my vision, only used for night-time driving, quite transparent and relatively small, I can't really see how it might be an issue, especially with the safety gain it provides.

Keehan Dowd,
Edmonton, Canada. SC

LEDS EXPLAINED

A basic insight into this exciting technology



Ever since Philips Lumileds created the high power LED over 10 years ago, the rapid advancement and development of solid state lighting components has facilitated exciting new applications and innovations. If we gaze around our environment, we notice just how wide. spread the use of LED technology has become.

by Ross Spina (RMS Parts Pty Ltd)

LEDs are everywhere, in just about every household appliance, in our automobiles, in our computers and also in our lighting fixtures.

In fact it is the lighting industry which is gaining the most in the use of LED Technology. The push for greener, environmentally friendly lighting solutions means that LEDs have become the viable alternative solution to incandescent and fluorescent lamps.

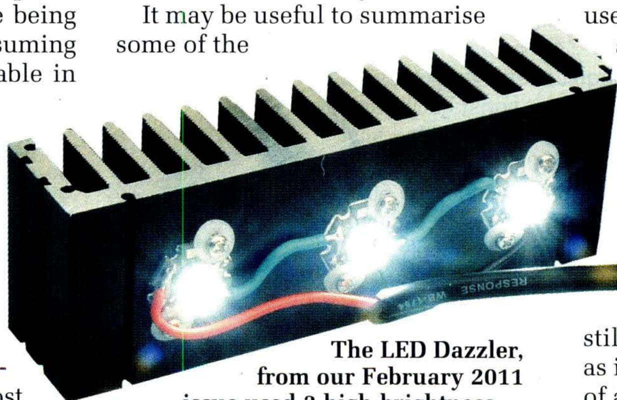
Where the reliability of CFL products is questionable, LEDs are being promoted as more reliable, consuming lower power and more adaptable in their applications.

However the adoption rate of LED lighting in consumer homes is still relatively low. This is due to the high expectations which have been placed on the cheap imports and their failure to deliver.

Within the industry there are many myths about the reliability of LED products. The most common relates to the lifetime of LEDs. There is a general belief that LED fittings will last 50,000 hours with 70% of the initial lumen output. This is simply an exaggeration.

To put this statement into perspective, a LED fixture would need to be utilised for 12 hours a day over more than 11 years before we could expect partial or total failure. Any electronics engineer will know that the fitting is only as good as its weakest link. Given that LEDs often require complex circuitry and adequate cooling to operate, it is unrealistic that we should expect this level of reliability.

It may be useful to summarise some of the terminology used in High Brightness LED specifications. LED distributors are often asked to explain some of these terms to clients.



The LED Dazzler, from our February 2011 issue used 3 high-brightness Seoul Semiconductor LEDs and came with a warning: don't look into it!

Luminous Flux (or Lumens)

This is probably the most prominent information provided by any high-power LED manufacturer – and also one of the least understood.

It simply measures the total amount of light emitted by the light source and is measured in lumens (lm). On its own, this information is not very useful other than to provide a comparison of the total output of one light source when compared to another. Accordingly it is likely that this information will be marked on the packaging of most light bulbs or light fixtures.

Traditionally the output of low power or indicator LEDs has been measured in candelas (cd) or milli-candelas (mcd). This is still a valid unit of measure for LEDs as it measures the luminous intensity of a light source in a given direction.

If you focus a LED light source into a narrow beam, this will increase the

How does a LED produce light?

All light is produced in the same way – from an electron giving out energy as it jumps from an excited state back into its standard orbit around its nucleus. That holds true whether we are talking about light from the sun, light from a chemical explosion, light from an incandescent bulb filament, light from a fluorescent tube, or light from a LED.

Of course, the mechanism varies just a little between each. In a bulb, for example, the filament (resistance wire) is heated by current, forcing electrons to jump into a higher orbit around the nucleus. They're not happy in that excited state and try to jump back into their "normal" orbit. Energy (photons of light) is given off as they do so.

It's not too dissimilar in a LED, except that the action does not rely on heating. An applied voltage forces electrons across the P-N junction. The electrons change state as they cross the P-N junction, losing energy (voltage) in the process, which is emitted in the form of a photon. With this happening countless millions of times, the photons all add up to produce light we can see.

The colour of a LED is determined in two ways: (1) by the material used to make up the P-N junction, and (2) by phosphors which are coated on the LED surface and glow with particular colours. White LEDs, for example, use a yellow phosphor which mixes with the blue glow of the LED itself.

light intensity, thus increasing the candela rating. While this is a practical measurement for indicator LEDs, it has no real purpose for lighting applications. LED lighting needs output in much more than one direction.

However, it is still common to be asked for the relationship between candela and lumen output despite the fact they are measuring different lighting characteristics.

There is no direct correlation, suffice to say that the narrower the beam angle of the light source, the greater the cd/lm ratio.

Frequently you will see that LED manufacturers will market a product with a very high luminous flux output. This is not a determinant for a very high quality LED. It is simply a comparative measure that designers may take into account if they require a light source with this much output. LED manufacturers (that is, the actual LED) use this measure as the primary means of sorting or "binning" their products after the manufacturing process. A white LED data sheet usually provides a typical luminous flux output for a particular part. However a separate, more detailed listing will usually advise the range of available "bins". The highest output bins will be sold at a premium price where the manufacturing yield is not so high.

Using the basic fact that a typical-white LED is basically a blue LED associated with a yellow phosphor coating, the cooler the shade of white, the higher the luminous flux.

In the February 2011 edition of SILICON CHIP, the LED Dazzler article demonstrated the luminous flux of the (white) P7 LED made by Seoul Semiconductor. This device can deliver around 900lm when fully driven at 2.8A. It sells for approximately $18ea in small volume. Another high power LED is the XM-L made by Cree. This device can deliver up to 1000lm at 3A. It can be purchased in Australia for around $10ea.

These products both represent exceptional performance in terms of Luminous Flux from a single LED.

However, just to confuse the discussion, Luminaire (that is, the fittings incorporating LEDs) manufacturers do not specify their fixtures just in terms of luminous flux. This is because this is a measurement taken from the light source.

It is usually more practical to explain the performance of a light fitting in terms of its effective light output at a measured distance from the source. This measurement, also known as illumanance, is used to quantify the incident light radiated from the light source and is described as the lumens per square metre (lm/m^2) or Lux.

Luminous Efficacy (Lumens/Watt)

Luminous efficacy is a more useful measure of determining LED efficiency. It is the ratio of luminous flux to power consumed and is measured as lumens per watt (lm/W). Accordingly, the higher the lumen output per watt, the less power required to generate the same amount of total luminous flux.

In terms of LED performance, this

figure is constantly improving for manufacturers and some top performing white LEDs are currently able to offer in excess of 120lm/W. When compared to Halogen bulbs or CFL tubes which offer between 10-50lm/W, it is possible to see why it is quite practical to save power by utilising LED technology fixtures.

Fluorescent tubes range from about 16 to over 100lm/W, depending on their size/type and the ballast type.

Lighting manufacturers use this information as the basis for developing LED lighting fixtures with the following consideration. Inherently, high power LEDs get very hot as large amounts of current are passed through their small profile. This heat must be dissipated efficiently to keep LEDs working within their design constraints.

As the temperature of the LED rises, luminous efficacy reduces proportionately. Most LED dies have a relatively linear luminous efficacy up to their maximum operating temperature. This is typically around 85°, although some manufacturers will provide operating temperatures up to 125° before their efficacy is compromised.

Efficacy directly affects the size of heatsink required to dissipate heat. The greater the efficacy, the less power is needed to generate the same amount of light and the need for more elaborate heat-sinking is reduced.

The Luxeon Rebel, for example (manufactured by Philips Lumileds) has one of the highest maximum operating temperatures within the industry. The Rebel will operate at 125° while still delivering a high luminous efficacy. This is an important consideration where a light fixture needs to operate at a very high ambient temperature or there are issues in dissipating heat effectively.

Correlated Colour Temperature (CCT)

In basic terms, the correlated colour temperature (CCT) describes the colour emitted by an LED and is measured in Kelvin (K). For white LEDs this is normally used to describe light output as either a warm, natural or cool white. Warm white tends to be towards the red end of the spectrum while cool white is towards the blue. Theoretically, natural white contains an even mix of colours and roughly equates to the colour produced by the sun.

Generally LEDs with a CCT of between 2700-3500K are considered as warm white LEDs and typically replicate the colour temperature of a standard incandescent lamp or metal halogen bulb. LEDs with a colour temperature of between 3500 – 5000K are considered natural white. LEDs above 5000K are considered cool white and will output light with a bluish tint.

Reproducing the same colour temperature on a LED is a difficult process and not an exact science. Because a typical white LED is merely a blue LED with a phosphor coating, it is often the thickness of this phosphor coating that determines the colour characteristic of the LED.

Unlike coloured LEDs which have a dominant visible light wavelength, white LEDs filtered from a monochromatic light source (such as blue or UV) will produce a broad spectrum of wavelengths. It is easier to "bin" them according to their Chromaticity (x and y) coordinates on the CIE chromaticity chart.

Colour binning is an important issue which affects luminaire manufacturers. Surprisingly, minor differences in colour temperature on LED arrays can often be easily spotted and impacts the overall quality of the fixture.

Therefore it is important to specify exact requirements in relation to CCT. Generally the LED distributor or reseller will offer "open" bins at the lowest price which means you don't necessarily get the exact same product on subsequent orders – buyer beware.

It's a bit like colour variations in ceramic tiles, bricks and wallpaper.

Colour Rendering Index (CRI)

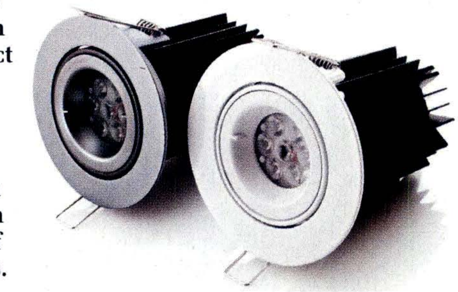
Another important criteria of LED Lighting is determining how faithfully the light is able to reproduce the colours of various objects in comparison to natural light. This is referred to the Colour Rendering Index.

If we assume that sunlight is able to faithfully reproduce all colours perfectly, then it would have a CRI of 100. The incandescent bulb and most halogen bulbs have a CRI greater than 85.

By comparison, some of the low pressure sodium lighting which illuminates our roads has a CRI of around 20 or less.

LEDs in the warm-to-natural colour temperature range typically have the highest CRI of around 85-95. Because

Soanar's Ecolume DL Series of down lights is the perfect replacement for power-hungry halogen down lights. The DL series operates on only 15W, with an operational life of over 60,000 hours.



of the nature of the broad spectrum white light radiated from a white LED, the subjective quality of the colour reproduction differs, depending on the dominant wavelength which may be present within this visible spectrum of light.

However the general consensus is that the greater the CRI, the better the quality of the light for illumination applications.

Forward Voltage (VF)

LEDs require a certain voltage across them in order to make them emit light. Because LEDs are obviously diodes (with an anode and cathode) current can only run in one direction – from anode to cathode. This is called the forward direction and the electromotive force, or voltage, required to push the current in this direction is called the forward voltage.

Most low power LEDs, such as those used for indicators, would normally have a forward voltage of around 2 – 3.5V (DC). Different colour LEDs have different voltage requirements – reds and yellows tend to be lowest, blues and whites highest.

However, high power White, Blue and Green LEDs are made from Indium Gallium Nitride (InGaN). This material is employed in the epitaxial LED layer because it is able to produce the shorter wavelengths needed for these colours. The disadvantage of this material is a higher forward voltage – typically the forward voltage is in the range of 3 - 4Vdc.

This specification becomes more critical when determining luminous efficacy. Using Ohm's Law, the lower the forward voltage of the LED device, the lower the power dissipation at any given current. And as the applied current through the LED is increased, so does the forward voltage. Hence, the luminous efficacy tends to drop as the current (and thus power) is increased

An example of the heatsinking required on Ultrabright LEDs – this CREE LMH6 has a light output of 2900 lumens – but it also needs to get rid of a significant amount of heat.

So peak efficacy is not usually at full power and is often quoted at below maximum power.

Thermal resistance

This characteristic of a LED is an important issue in determining how hot it is likely to get during its operation. The higher the thermal resistance of the LED, the more difficult it is to get the heat away.

Unfortunately the performance of a LED is compromised as the temperature of the device rises. At very high temperatures, the lifetime of the LED is significantly reduced; even catastrophic failure can occur.

It's much better to have a lower thermal resistance because it is easier it is to dissipate the heat away from the LED chip. Thermal resistance is measured in degrees per Watt (°C/W).

The thermal resistance of a LED is related to its structure/composition. The original high brightness Luxeon 1 LEDs manufactured by Lumileds were constructed in a plastic case with a plastic primary optic. These devices had a 1W rating and had a junction thermal resistance of approximately 15°/W. The current Luxeon Rebel ES series, with a ceramic substrate and a bonded metal interconnection layer, as well as a silicon lens, has a rating of approximately 6°/W.

Manufacturers use various materials in order to reduce thermal resistance and increase thermal efficiencies. However ALL high-brightness LEDs must utilise some form of heatsinking to ensure that the junction temperature is kept to a minimum during operation.

Earlier, we mentioned the fallacy of LED fixtures operating for 50,000 hours. The lumen maintenance data provided by many LED manufacturers is extrapolated from a simulation which tests the LED for a shorter peri-

Ultrabright LEDs need drivers

Getting light from a low-power LED is easy: just hook up DC power in series with a suitable resistor (which you can work out easily from Ohm's law).

Ultrabright LEDs *can* be driven the same way but it's very inefficient. They really need a purpose-built constant-current driver, such as this MORNSUN KC24W.

It's a high-power LED driver designed as a step-down constant current source. With its high efficiency, wide input voltage range, and PWM dimming and analog dimming function selectable, also with remote shutdown capability.

The KC24W series can be widely used in 12V, 24V, 36V and 48V landscape lighting, special lighting controls, commercial lighting, automotive lighting and many other commercial and domestic lighting system applications.

The leaded package allows for more convenient use where no PCB is required or desired.

The KC24W series is a high efficiency device (up to 96%) with an ultra-wide range voltage input and output (5.5-48 VDC), output current accuracy (±2%) with high output current stability(±1%) and low ripple & noise (<100mV) suitable for use with large capacitive loads (1000µF).

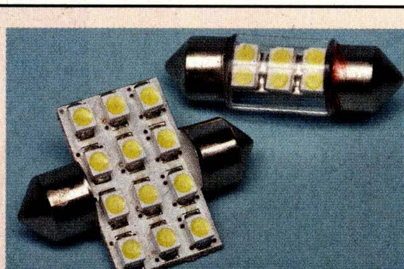
The KC24W series is also suitable for either PWM or analog dimming and is even waterproof to the IP67 standard.

LEDs in automotive use

Not long ago the festoon (dome) light in my car failed – and instead of replacing it I bought these LED replacements (about the same price as the globe!). They are dramatically brighter, especially the 12-LED version at left (the 6-LED is exactly the same size as the festoon globe).

Just as importantly, the current drain has reduced from ~250mA to <100mA and the heat generated is also way down.

Of course, these are just one example of LED use in vehicles these days: tail lights,



stop lights, truck clearance lights, indicator and dashboard lights . . . and there are even some vehicles now with ultrabright LED headlights!

od under multiple adverse conditions.

The accepted standard for lumen maintenance is known as the IES LM-80 test standard. The test requires manufacturers to test LEDs for a minimum of 6000 hours at 1000 hour intervals and at three case temperatures (55°C, 85°C and one other temperature as selected by the manufacturer). The test requires an ambient temperature of 25°C.

Unfortunately most fixtures do not operate in an ambient temperature of 25°C. Instead it is likely that a downlight fixture could be operating in a harsh environment of 60°C or higher.

Accordingly it is important to use appropriate heatsinking materials to ensure that heat is dissipated away from LEDs. This forms the most crucial aspect to LED Lighting and the most difficult to design.

The problem which arises is the large cooling area (including complex fin design) required to dissipate enough heat from the LED junction. Also required is an efficient heat conduction mechanism such as thermally conductive tape or grease compound which interfaces the LED and heatsink.

AC LEDs vs DC LEDs

While AC LEDs have been available for several years, the adoption rate in Australia has been slow.

This technology incorporates complex dies made up of multiple LED junctions which are able to withstand a forward voltage equivalent to 230VAC (for Australian requirements).

There are several immediate benefits in using AC LEDs for lighting applications. Firstly, the design is much simpler, allowing a fast time to market. This is because there are no requirements for costly or complex power supplies to drive the LEDs.

Secondly, there is a reduction in size of the light fixture since there are no other components required. Most importantly, AC LEDs are not polarity conscious, whereas DC LEDs can be damaged or destroyed if connected in reverse.

However there are some implications which need to be considered. Like any other 230V device, there are safety/legal issues which need to be taken into account within the design.

This is the main reason why AC LED technology has been slow to develop but there are other reasons – the complex dies do not have the same lifespan as DC LEDs and they generally have a lower efficacy meaning that their overall performance is lower than their DC counterparts.

To overcome the some of the safety implications, both Seoul Semiconductor and Philips Lumileds have developed a range AC LEDs with an operating voltage of between 50 – 55V which can be configured for 230V operation and have an RMS operating current of 20-30mA.

These devices require minimal additional components to operate and they are an excellent alternative to the low voltage DC LEDs in some applications.

Summary

It becomes obvious that there is more to it than just connecting a power supply to a LED to make a lamp fitting.

Without an understanding of the realtionship between all the technical factors mentioned, it's not an easy task to design LED lighting for the home or office. It's best to understand the various pitfalls so as to avoid them.

Fortunately there is a truckload of information available from the internet which is useful for both buyers and designers alike. Most of the major LED manufacturers also provide ample information about their products including some excellent design briefs.

For pricing on any products from the manufacturers listed in this article, please contact the relevant distributors.

In Australia, Cree is distributed by Cutter Electronics, based in Melbourne. Seoul Semiconductor is distributed by RMS Parts based in Brisbane. Lumileds are distributed globally by Future Electronics. **SC**

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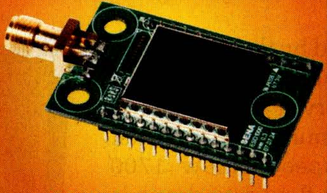

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Can you *really* reduce your electricity bill?

By JOHN CAMERON*

With recent large increases to commercial and domestic electricity tariffs and promises of more to come, everyone wants to know how to reduce their electricity consumption. This *can* be done but it is neither simple nor easy. In this article we will review some strategies for saving power – and debunk some of the scams around!

The review of the FutureWave Energy Saver for swimming pool pumps in the June 2011 issue of SILICON CHIP has created a lot of interest.

It really does work, unlike most energy saving gadgets promoted to an uninformed public.

There are two main types of energy 'saving' devices sold over the Internet, at flea markets and unfortunately, by some retailers who should know better.

Most are so-called power factor correction devices or devices which are claimed to "clean up" or otherwise fix your "dirty" or "unusable" power. These provide no benefit to domestic consumers and have been frequently discredited. (See the November 2007 and May 2008 issues of SILICON CHIP).

Less common power saving products are voltage reduction devices for electrical motors. They vary the voltage to the motor, depending on the load. More on these devices later.

Possibly some readers may have suspected that the FutureWave device reviewed in the June 2011 issue was just another device varying the voltage fed to the motor. But the review gave a different picture.

It is intended for controlling swimming pool pumps which are driven by induction motors.

The FutureWave reduces the supply frequency fed to the motor, as well as manipulating the voltage and waveform.

The end result is reduced motor power consumption while still providing adequate torque and power output.

This is the real advantage of the FutureWave compared to anything else on the market.

It was determined by the developers of the FutureWave Energy Saver, after studying pump curves and graphs of pool pumps and much testing, that dropping pump speed below 1700 RPM, the resulting flow rate drops is not adequate for effective filtering.

Hence the lowest flow setting on the FutureWave is 31.5Hz, giving a pump speed of around 1800 RPM (for a 2-pole induction motor with a nominal speed of 2850 RPM) and allowing flow rates to be maintained to adequately maintain filtering and cleaning performance.

On average. this will provide a power saving of about 70%,

Where do the savings come from?

The savings come about because swimming pool pumps are over-specified for normal water filtering. The FutureWave provides large savings by reducing the flow rate through the pool's plumbing to a rate better suited for efficient pumping and filtering.

So why is the pump not the ideal size for normal water filtering? It is basically because a larger pump with enough power output is required to prime the pool's plumbing system, run

The FutureWave Energy Saver was reviewed back in the June 2011 issue. It's one device which really *can* cut your electricity bill if you have a pool!

a pool cleaner and provide adequate flow to perform backwashing.

The FutureWave allows the pump to prime the pools plumbing system before its energy saving mode kicks in. It will then reduce the power consumption whilst providing adequate flow rates to operate the pool cleaner (eg, Kreepy Krauly). A pump has to be able to pump 120-180 litres/minute against a reasonably high 'head' (eg, the depth of the pool plus height of pump above the pool) to keep the cleaner operating.

When the cleaner is not in use, ie, when the pool water is simply being filtered, the pump does not slow down. It continues to pump hard, forcing lots of water though the system.

This is not efficient because the friction loss in the PVC pipes of the typical swimming pool rises as roughly the square of the water flow.

So when you double the flow rate the friction loss of a system increases by a factor of four. In other words, you need four times the power to pump 240 litres/minute around a pool system compared to 120 l/min.

This was seen with figures given in the June FutureWave article. A 40% reduction in motor power frequency and thus water flow gave over a 60% reduction in power consumption. Halving the water flow rate would give a 75% reduction in pump energy needs.

In effect, the FutureWave Energy Saver converts a normal swimming pool pump into a variable speed pump that can be scaled to better meet water pumping requirements, giving energy savings when high water flow rates or pressures are not needed.

Variable speed pumps

So why not simply use a variable speed pump?

In fact, they are available, from most swimming pool shops. A typical example is the Hydrostorm ECO which has three speed settings (2850 RPM, 2410 RPM and 1900 RPM) and which according to waterco.com.au can slash its energy use by up to 67%. It costs about $1,200. See: www.waterco.com.au/pool-spa/11-hydrostorm-eco-three-speed-pump-

There are a range of other variable speed pumps including the Zodiac FloPro ePump which has up to eight different speeds (www.zodiac.com.au/products/pool-pumps/flopro-epump)

We looked at this "Electicity Saving Box" back in November 2007 and proved it wasn't even worth the box it came in . . . nothing has changed, except now there are lots more of them around. Don't believe the claims: they're a con!

and the HurlconViron P300. See www.rodepools.com.au/content.php?pageid=1276835758

These variable speed pumps all use brushless permanent magnet motors which are driven by switchmode controllers.

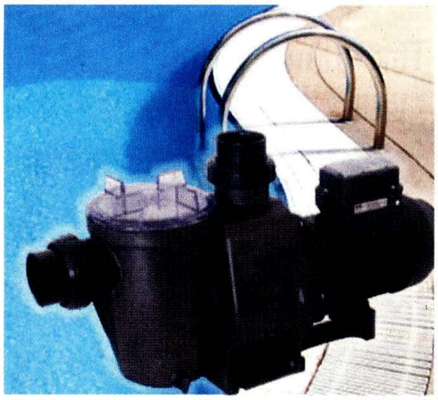
Not only do they have the advantage of lower power usage, they are also substantially quieter than typical pumps driven by induction motors. That gives a further advantage in that they can be run from off-peak power at night without disturbing neighbours.

We should note that the developers of the FutureWave Energy Saver have pointed out that "while variable speed brushless DC motor driven pumps may claim over 70% savings, they also mention that at the reduced pump speed (600-800 RPM) the flow rate is reduced to 80-100 litres/minute, well below the required flow rate for a filter and cleaner to perform adequately."

From talking to people in the pool industry it appears that customers are reluctant to spend more on variable speed pumps or on water filters, above the minimum required.

The initial cost is an issue. A regular 750W (1 HP) pump typically costs about $400-500 and a 1.5HP unit only slightly more. Compare that to a new variable speed pump which costs $500 to $1000 more to install.

In the past the running costs have not been a major concern to customers at the time of the pool or pump purchase.



Hydrostorm's ECO pool pump and filter – it looks similar to most standard pumps but features a variable speed motor.

But with skyrocketing electricity costs, that is now changing rapidly and people are likely to be far more sensitive to electricity bills.

In practice many pools would be better cleaned if they had a larger filter and a smaller pump. Filtering works best at lower flow rates.

We understand that Sydney pools typically use 1HP pump motors with 1.5HP motors being mainly limited to 80,000 litre and larger pools.

It is also possible to separate pool filtering and cleaning. Pool water filtering can be done with a smaller pump, typically 0.5HP, with the automatic pool cleaner running off a booster pump when required.

Finally, for the lowest energy consumption, swimming pool shops sell a number of electrically-driven pool cleaners (often described as pool cleaning "robots").

These are powered by 24V DC motors and are very energy efficient. They typically draw about 100-150W when running.

A low-voltage (24V DC)swimming pool "robot" cleaner. They're claimed to save money because they are not reliant on a large pool pump working hard to control them. They are suitable for all sized pools including large commercials.

Similary, the Hurlcon Viron P300 also sports a variable speed motor. At about $965 it's not cheap but claims power savings (at 2010 prices) of up to $700 per year over conventional (ie, constant speed) pumps.

Overseas experience

Oversized pool pumps are not just an Australian problem. In a study of 120 pools by the USA Center for Energy Conservation at Florida Atlantic University, some pool owners saved as much as 75% of their original pumping bill by replacing large pumps with smaller pumps and by simply reducing running time.

The study showed that a 0.75 horsepower (600 watts) or smaller pump is generally sufficient for residential pools.

By the end of this year Florida will ban the sale and professional installation of single-speed pumps of one horsepower or greater for domestic swimming pools.

Also, California has, as you would expect, a large number of swimming pools and has studied pool energy requirements in detail. See **www.energy.ca.gov/title24/2008standards/prerulemaking/documents/2007-02-26-27 workshop/supporting/PGE-DRAFT REPORT RESIDENTIAL SWIMMING POOL.PDF**

In summary, the most economical pool system is one designed for efficient water flow and fitted with a variable speed motor.

The simplest option for most people would be to reduce the filtering run time for their existing pump as far as possible and when the pump motor is next replaced install a multi-speed motor.

Energy saving devices

As already noted, simple capacitor-based power factor correction boxes do nothing in a domestic environment as far as power saving is concerned.

But other devices can *appear* to lower electrical consumption, frequently with impressive university reports setting out the electricity savings. But whether these devices actually save money is another matter.

They are intended for use with AC induction motors. They work by monitoring the motor and lowering the voltage when the motor is lightly loaded.

The monitoring technique was developed by NASA engineer Frank Nola to lower energy consumption in motors and fans on NASA-built vehicles. NASA still lists it as a NASA technology spin-off. Details can be found on the NASA web site **www.nasa.gov**

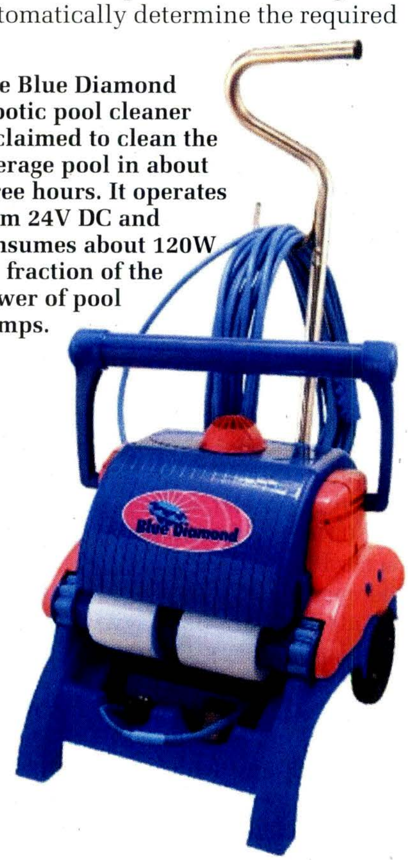
This concept generated a lot of interest during the 1990s and there were many manufacturers of these devices, claiming spectacular savings.

In simple terms, the device monitors the motor's load by measuring the power factor and then uses some sophisticated electronics to control the voltage to keep the power factor constant even as the load changes.

This reduces the losses in the motor when the motor is lightly loaded. Lowering the voltage of a synchronous motor does not change the motor speed but does reduce its torque.

The cleverness in Nola's work was how he used power factor changes to automatically determine the required

The Blue Diamond robotic pool cleaner is claimed to clean the average pool in about three hours. It operates from 24V DC and consumes about 120W – a fraction of the power of pool pumps.



voltage adjustment so that power increased when more torque was needed. Microprocessor-based integrated circuits are available to handle the device smarts, for example the Microchip MTE1122.

A typical device sold to the public for domestic appliances is the Reegen uPlug power saver, marketed widely around Australia in 2009.

Results on *unloaded* motors using this device can be impressive. For example, tested it with a 0.3 HP drill press motor, readings fell from consuming 190W to 145W, an apparent 25% reduction. But operated under heavy load – in other words, working as intended– it showed NO power saving.

In a domestic environment they do not save money.

Tested on a wide range of devices such as refrigerators and washing machines, there are minimal electrical savings on most devices because their motors are already running at close to full load.

In fact, the claimed savings all seem to be on motors running with no load. Details of some studies of these devices with a range of motor sizes can be found at **http://home.clear.net.nz/pages/lmphotonics/es090698.pdf**

Refrigerators are an interesting case and show that simply measuring the power consumption (ie, watts) can be misleading. I have tested refrigerators that show a 5-10% power saving on a commercial wattmeter.

But when total energy used over 24 hours is measured there is no saving. This is because the refrigerator simply ran for longer times when on the energy savings device. It still had the same amount of work to do to cool the contents.

In summary, **these devices provide no benefit in the normal home**, especially as they typically cost $200 to

The Micro Plug Power Saver: first released a couple of years ago, these were supposed to connect to electric motors and save you money. Did they work? On motors with no load, yes. But how many motors run with no load? At $198.00 each, your grandkids (or theirs) might see a payback . . . but we doubt it!

$500. For an overview, see http://www.bar-fridges-australia.com.au/pdf/reegenmicroplugpresentation1.pdf

Voltage optimisers

"Voltage Optimiser" devices are another recent development. They have appeared across Australia with marketing targeted at clubs and small businesses wishing to lower their electricity bills.

The promoters claim to "reduce electricity cost by up to 20%" by better controlling the voltage.

The optimiser is frequently a transformer that reduces the supply voltage to the area or site. It is difficult to see how installing these voltage adjustment devices can save money by themselves.

If simply lowering the mains voltage to a device made a major difference to energy consumption you would presumably have larger electricity bills if you lived in an area with higher voltages.

In Australia our electricity supplies run at a nominal 230VAC but can be anywhere between 216 and 253VAC.

Until 2000 the nominal voltage was 240VAC and there were a number of studies done during the 1990s on what impact a change of voltage would have on typical domestic appliances.

In practice it was found that voltage changes have minimal effect, particularly for motor-driven devices.

One particular study, that in the 1990s by the University of Ballarat, which included substation monitoring, concluded that voltage variation has minimal effect on energy usage.

For further information see http://itee.uq.edu.au/~aupec/aupec04/papers/PaperID77.pdf

It stands to reason: simply lowering the voltage to an air conditioning unit does lower its power reading in Watts – therefore you apparently use less power – but to maintain the same temperature, the unit now cycles so that it is on for longer.

Total energy consumption and cost will be unchanged.

In reality, it would be very difficult for customers to tell if voltage optimisers really are giving a cost saving. In particular, refrigeration or air conditioning unit energy consumption depends heavily on ambient air temperature.

There are any number of websites where enthusiastic suppliers show actual energy bills to "prove" their point. But showing energy savings by comparing electricity bills can be simply showing different average air temperatures.

For example, a colleague remarked the other day that this past winter (2011) is as cold as he can remember, having used his air conditioner on all but about ten nights. Compare this with the mild winter of 2010, where he recalled using the air conditioner for ONLY about ten nights!

To my way of thinking the best way to make a real saving is to adjust the thermostat on the air conditioning to be closer to the ambient temperature and to turn devices off when they are not needed.

The only case where these energy devices are cost effective is where motors run at well under their design load for long periods, for example escalators or conveyor belts that are only intermittently loaded.

Escalators must be designed to allow for two people on every tread – yet they work day in, day out often with virtually no-one on them. (Modern buildings often have escalators that either stop or slow right down until someone steps on them).

This intelligent power meter from Jaycar Electronics simply plugs into a normal power point (GPO) and turns it into a real-time power monitoring outlet. You can enter the local price of your electricity and the meter will tell you exactly how much the appliance is costing to run.

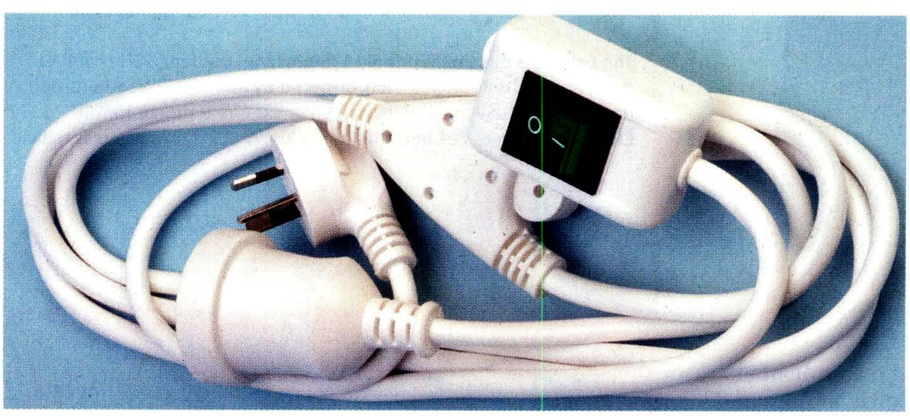
Similarly, conveyor belts need to cater for worst-case scenarios but often have significantly less than maximum usage.So be very wary of any company who claims that their device substantially lowers power consumption and costs by modifying the mains voltage. A reduction in power (Watts) will almost certainly be offset by longer running time. Total energy use (kWh) and cost will be unaltered.

Lighting? Tiny savings *are* possible

The only area where voltage does have a more than minimal effect is lighting, where power consumption and light output are roughly proportional to voltage.

The newer fluorescent lights (both compact fluorescent and those with electronic ballasts) draw a constant current and are much less sensitive to voltage than incandescent lamps. But the same saving can be obtained by using lower wattage light bulbs.

What's more, some bargain CFLs



If reaching behind cupboards to turn things on and off isn't to your liking (or maybe the floor is too far away!) this Ecoswitch allows you to put the on/off switch wherever you find convenient. It's great for home theatre systems.

can be responsible for a higher power usage than quality, brand-name units (although even this is not always the case).

You see a lot of comment in the popular media about turning lights out when not in use but the truth is that lighting represents only a tiny percentage of overall household power consumption.

Some other, admittedly marginal savings can be made by reducing the "on" time of sensor lights, particularly outside floodlights which tend to be a bit more power hungry. If whoever/whatever caused them to trip is still moving around out there, they'll come back on again!

Overall though, you're not going to save any real money by modifying your lighting usage (with the possible exception of large outside floodlights).

Standby power

It is estimated that a typical household uses up to 100W in standby power – they're all the things that are turned on by remote controls, or by pressing "soft start" buttons.

100W continuous adds up to about 875kWh a year and at (say) 25c/kwh, will cost you a couple of hundred dollars or so a year.

So can you save this by turning everything off at the power point?

Yes you can – but you will often lose a lot of convenience. Anything with a clock may well lose its settings, as may many other devices which rely on standby power to keep their memories active. Some devices, such as Foxtel boxes, can take quite a while to reset themselves.

It can be a real pain to have to reset everything each time the power goes back on!

But you can – and arguably should – turn off quite a number of devices such as computers and monitors, amplifiers, indeed most home theatre equipment, ceiling fans/lights, and so on.

Often it's very inconvenient to reach a power point to turn devices on and off (another reason most people don't bother!) but Carbon Reduction Industries have a handy "Ecoswitch" which brings the switch up to where it's convenient. The socket end can connect to powerboards, etc, if required (www.ecoswitch.com.au).

Magic Bullets?

Sorry – there are no magic bullets. In the end it is as simple as making certain you understand where your electrical energy is used and that any inefficiencies are removed.

The best energy saving device you can try is one of the cheap and cheerful energy meters available from Jaycar, Dick Smith and other stores. They are reasonably accurate and include power factor measurement.

Those tried are within 2% of commercial meters. Their main disadvantage is limited resolution in measuring energy consumption (usually kWh, not Wh) over a period and also some can be "fooled" by complex waveforms when measuring low-power switchmode devices.

In conclusion, there is only one golden rule in assessing promised energy and cost savings: "*Only energy that is being wasted can be saved*". **SC**

* This feature was inspired by, and largely based on, a contribution by John Cameron, with additional material by Leo Simpson and Ross Tester of SILICON CHIP.

How they shot the world's

When it was "taken" late last year, the photo above of the city of Seville, Spain, was a world record at 111 gigapixels. If printed out, it would be bigger than two football fields. And you can zoom in to show amazing detail. But shooting such a photo was no mean feat . . .

Lest we be accused of the bearers of old news, this photo is no longer the world record holder – that honour (currently!) goes to a similar type of photo of Shanghai, China, at 120 gigapixels.

We thought the story of the Seville photo was really interesting and if SILICON CHIP readers wanted to do the same thing for their fair city, it will give you some idea of the trials and tribulations involved!

Before we get too far into the story, perhaps you'd like to have a look at the photo (and have a play). You'll find it at **www.sevilla111.com/default_en.htm.**

OK, back again? I'll bet you just wasted an hour or so, right?

Sevila 111

The photographers, José Manuel Dominguez and Pablo Pompa, wanted to capture the magic and charm of their home city and make it available for people around the world. The result of several months of work was, when completed, the largest panoramic photograph in the world – 613,376 by 181,248 pixels.

The project was commenced in March 2010 with the selection of a suitable site from which to photograph the city. After examining and rejecting several sites, the Torre Schindler (a 60m-high observation tower on the banks of the Guadalquivir River) was chosen.

As well as offering a solid platform on which to mount the camera gear, it offered a 290° view of the city from not-too-far away from the centre of the city.

The downside was that the tower was being refurbished at the time, so instead of a high-speed lift to the top, they had to carry everything up 16 stories – and of course, back down again.

by Ross Tester

The camera gear

A Canon 5D MkII camera was used along with an effective 800mm lens (400mm plus 2:1 extender). The plan was to use an aperture of f16 and a shutter speed of 1/800S (ISO800). These setting resulted in a very satisfactory tonal range over the entire area.

A robot, built by the photographers, was used to move the camera to its next shooting position and open the shutter. Initially, aiming and shooting took about 4.8 seconds per image.

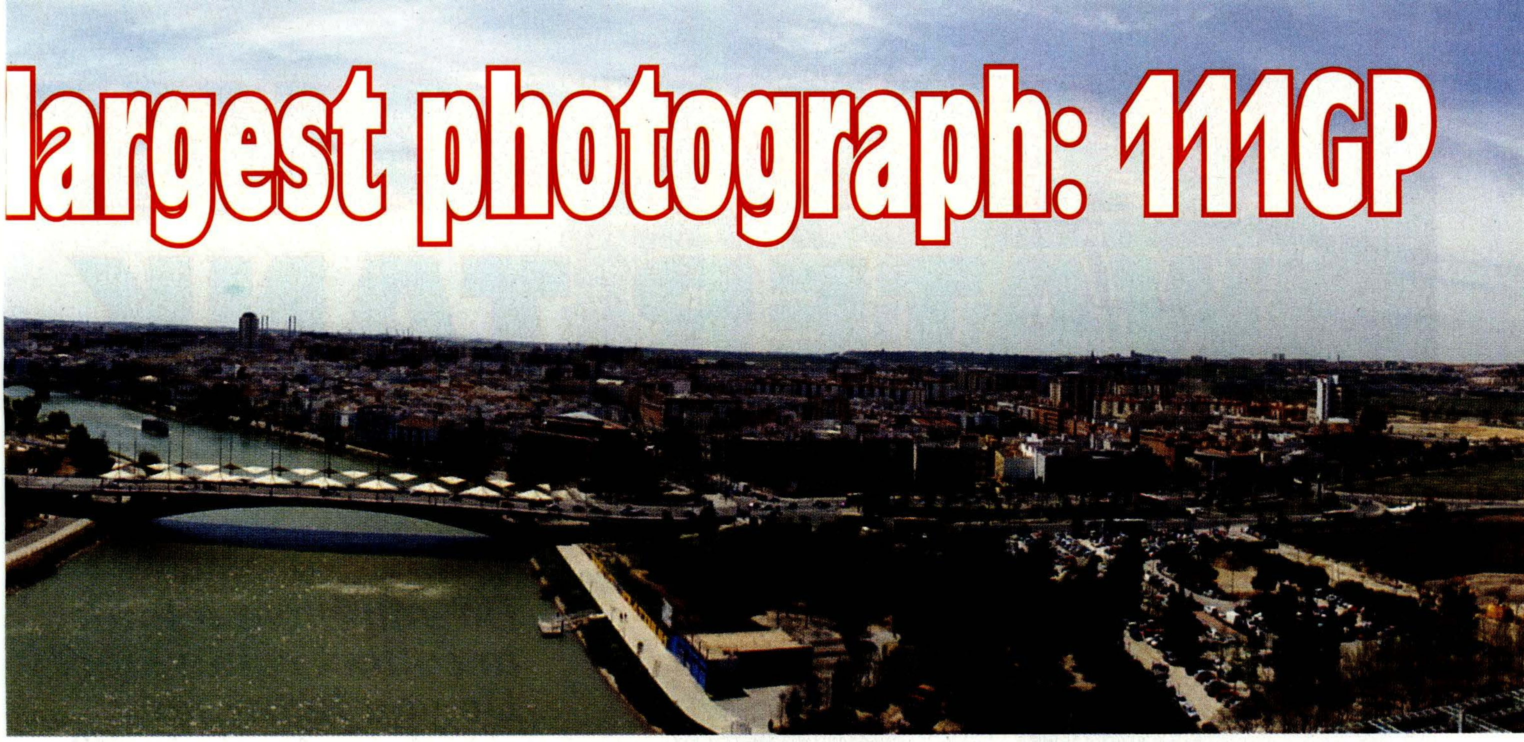
On the first test, they shot about 2000 pictures, covering 160° . But they soon ran into a couple of major hurdles. First was the weather itself – with the sun going behind clouds or sudden rainstorms resulting in vastly different exposures. More important, though, was the wind – which while virtually non-existent at river level created severe vibration and shaking at camera level. And an 800mm lens certainly exacerbates the problem. A third factor was the temperature itself – Seville in summer is quite a warm place, and the heat haze became a real problem.

The result was to postpone the shoot until after the summer.

Moving targets!

Initially, the goal was to shoot a world-record 60 gigapixel image but during the wait, others had achieved 70 gigapixel. The Seville team then changed their plans to achieve a 100+ gigapixel image. In the last

largest photograph: 111GP



days of September 2010 they shot about 14,000 individual frames – all told, they had shot 35,000 frames since April!

Computing power

To "stitch" together the images requires a computer with a lot of grunt. In the end, their PC had two 6-core Xeon processors, 40 gigabytes of RAM and an 8TB hard disk drive. They chose a software package which they were already familiar with, Autopano Giga.

Editing

To achieve the 100+ gigabyte target, they selected 9,750 images, 65 rows each of 150 images. Initially sorting was one using a .jpg image, rather than the RAW format which would have taken much more time.

They also had to discard all repeated images and images with incomplete elements, such as parts of people and cars. It took a full week to copy, review and sort all the images. Fortunately, only the images taken in late afternoon needed editing to match the others.

Problem!

They then ran into a major problem: the Autopano Giga 2.0 software simply wasn't powerful enough to handle 9750 images – in fact, it had a 5000 image limit. Fortunately, about this time the beta version (2.5) was available which had a 10,000 image capability. It also had a couple of welcome new features such as a haze filter and was significantly faster. But it was also buggy (being a beta) which caused lockups and crashes. Just when they were about to throw the whole project away, a new version came out which didn't have the bugs.

Final rendering

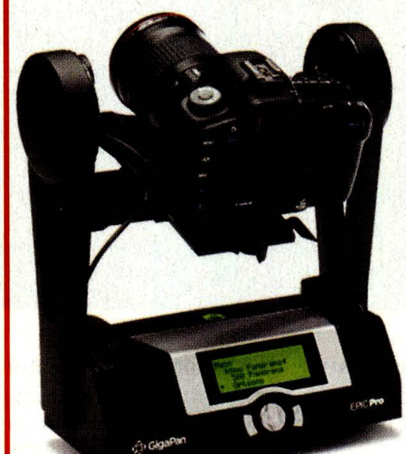
In mid November 2010 the final rendering of the files was commenced. There were three files, each one taking about 32 hours each. It took a whole week to render, then correct any rendering errors and finally blur people's faces and car number plates to avoid identification.

Viewing

KRpano software was used as a viewer because it works with Flash and is therefore compatible with most web browsers. This software also supports several interactive operations, which can be seen in the final image. The resulting panorama consists of 140,000 small images which are displayed on the browser as required.

Zooming in is possible to extraordinary level and moving back and forward over the panorama is also very smooth.

Psst! Want to shoot your own panorama?



While researching this story (honest, boss!) we came across this "Gigapan Epic PRO", a robotic camera mount which appears to do the same type of multiple-image photography as used for the above pic.

Strong enough to take a DSLR camera up to 4.5kg, the Epic PRO will take hundreds or thousands of detailed photos for one intricate Gigapan.

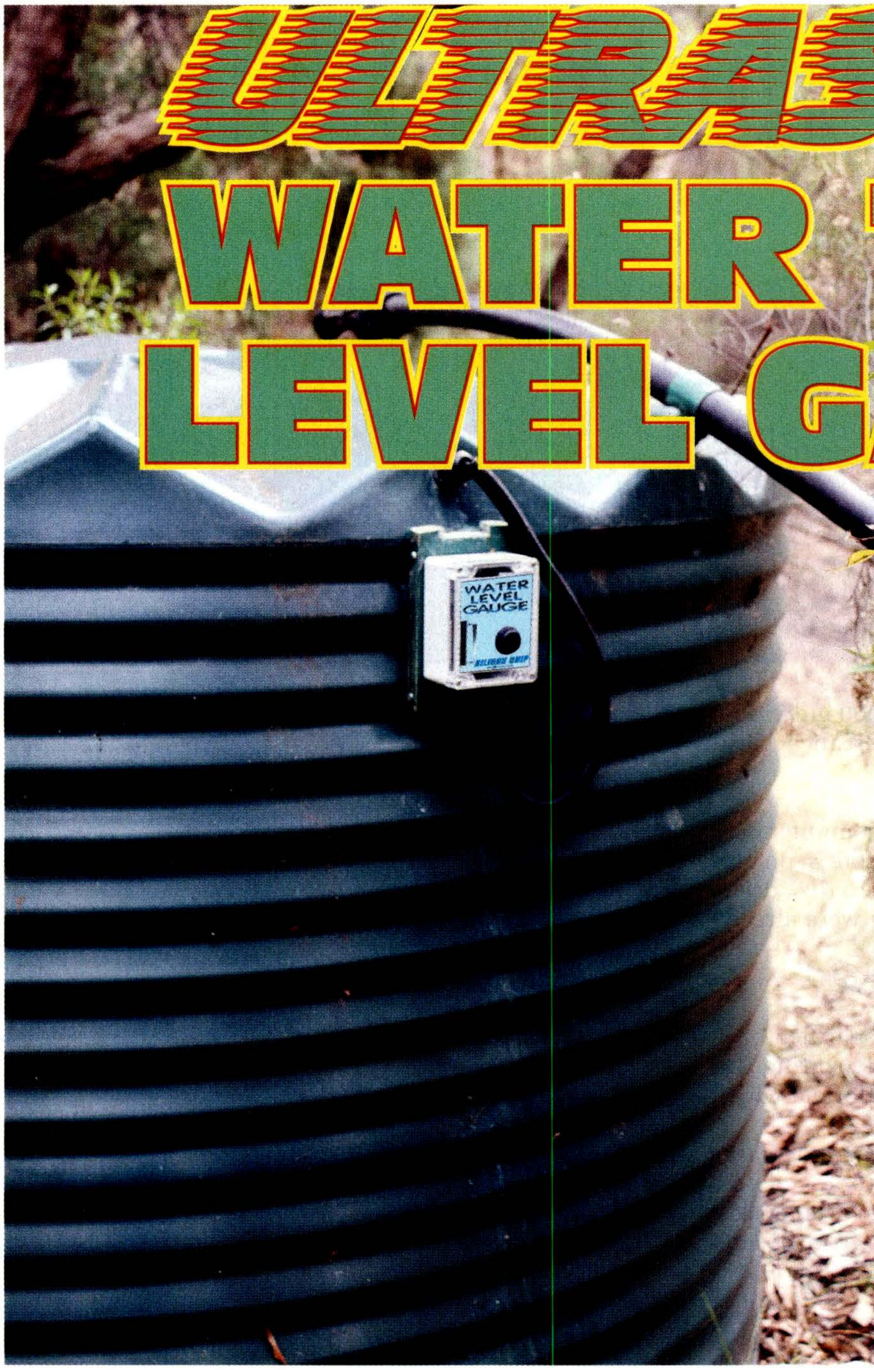
Coupled with the new Gigapan Stitch software, these photos are efficiently combined into a seamless panorama and uploaded to gigapan.com, where you can view, share and explore them.

The Gigapan Epic PRO offers a 360° panorama with +65° to -90° tilt range, to take into account even the most challenging mounting positions. Steps are 0.04°/step for tilt, and 0.12°/step for pan. It operates from rechargeable batteries (battery pack and charger are included. The Gigapan Epic PRO sells for $US895.00

More information? www.gigapansystems.com

SC

ULTRASONIC WATER TANK LEVEL GAUGE



Do you have a tank to collect rainwater? Do you know how much water is in it? This ultrasonic tank level gauge fires an energy burst which bounces off the surface of the water – and then a microcontroller calculates how far down the tank water level is. Clever, eh!

By JOHN CLARKE

Having your own rainwater tank is great – and very, very green! In fact, it's mandatory in most areas these days. If you just want to water the garden or wash your car in times of water restrictions, it's not that much of a drama if it runs out.

But if you depend on it for your daily water supply, it is crucial to know how much water is in the tank at any time.

This Ultrasonic Water Tank Gauge shows the water level using ten LEDs with a display resolution of up to 19 levels.

We have published a number of water tank indicators over the years, the most recent being a design based on a pressure sensor, in the November & December 2007 and January 2008 issues.

That design is still valid, especially as it also provides a 433MHz link to an LCD panel which could be mounted indoors – much easier to check the levels.

This new design is a simple standalone unit which is somewhat easier to install and has the benefit that the sensors are not in contact with or submerged under the water. And the ultrasonic measurement method is also suitable for fluids other than water.

The Ultrasonic Tank Level Gauge uses two waterproof ultrasonic sensors mounted in the air space above the water in the tank – one sensor transmits a burst of signal while the other receives it. The idea is that the water in the tank will reflect the signal and the time it takes for signal to be received, divided by two, accurately represents the distance between the water in the tank and the sensor.

This is done measured by a microcontroller, which then displays the result on a LED dot or bar graph.

It's very simple in principle but there

is a complication in that the speed of sound in air varies with temperature – and you can get a big variation in the air temperature in typical water tanks. It can range from below zero up to 50°C or more.

But never fear, the microcontroller compensates for that and computes a corrected reading.

Features

- Non-contact sensing
- Dot or Bar display
- Easy calibration
- Powered by 9V battery or DC plugpack
- Suitable for water or other fluids
- Temperature compensation
- Error indications

LED dot/bar graph display

The Ultrasonic Tank Gauge shows the water level on a vertical LED dot/bar graph display (selectable). In dot mode, 19 separate levels can be displayed, using only 10 LEDs.

How's that again? In fact, the dot display lights either one LED or two adjacent LEDs at a time, to show levels between each individual LED dot level.

For the bar graph display, ten separate levels can be displayed.

The Gauge is designed to suit many types of tanks, up to a height of 2.4m. It is powered from a 9V battery which should last a long time since current only flows for a brief time after the pushbutton switch is pressed to show the water level.

It is housed in a waterproof box with a clear lid so that the display LEDs can be seen.

Circuit

As already noted, the circuit is based on a microcontroller, a PIC16F88-I/P (IC1). It generates the 40kHz signal to drive the ultrasonic transducer, computes the water level and drives the LED bar graph.

As well, it monitors the air temperature inside the tank to provide compensation for the variations of the speed of sound at different temperatures.

Transistors Q1 to Q6 are used to provide push-pull drive to step-up transformer T1, which drives the ultrasonic transducer.

Outputs RB0 and RB2 of IC1 are configured to provide complementary 40kHz signals to drive the transistors. When no signal is being delivered, RB0 and RB2 are low at 0V and transistors Q1, Q3, Q5 & Q6 will be off. Transistors Q2 and Q4 will each be held off via the 10kΩ resistors between their base and emitter.

When RB0 goes high to about +5V, Q3 & Q5 are switched on. Q5 turns on Q2 and this pulls one side of T's primary winding to +8.7V. Meanwhile, the other side of the primary is pulled to 0V via Q3. After about 12.5μs, RB0 goes low, switching off the transistors Q2, Q3 and Q5.

RB2 now goes high to drive Q1 and Q6. Q6 switches on Q4. This reverses the current in the transformer primary and is maintained for about 12.5μs, when RB2 goes low and the transistors switch off.

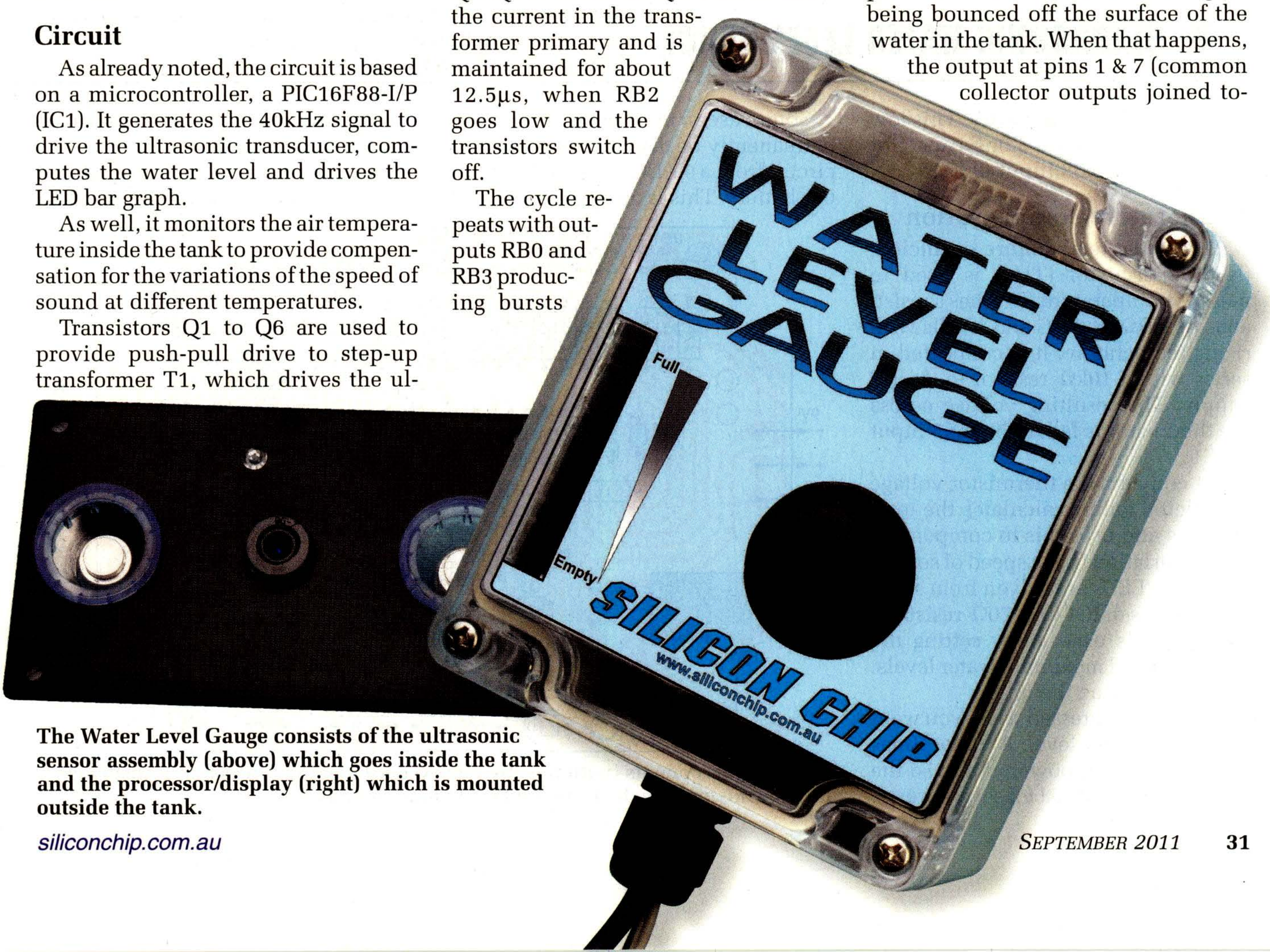
The cycle repeats with outputs RB0 and RB3 producing bursts of 40kHz which last for 15 cycles or 375μs. The transformer steps up the output primary to about 85V peak-to-peak.

Diodes D1-D4 clamp spike voltages induced by the transformer each time the primary current is switched off. They clamp the voltage to about 0.6V above the 8.7V supply and below the 0V supply rail to protect the driver transistors Q1-Q4 from over voltage.

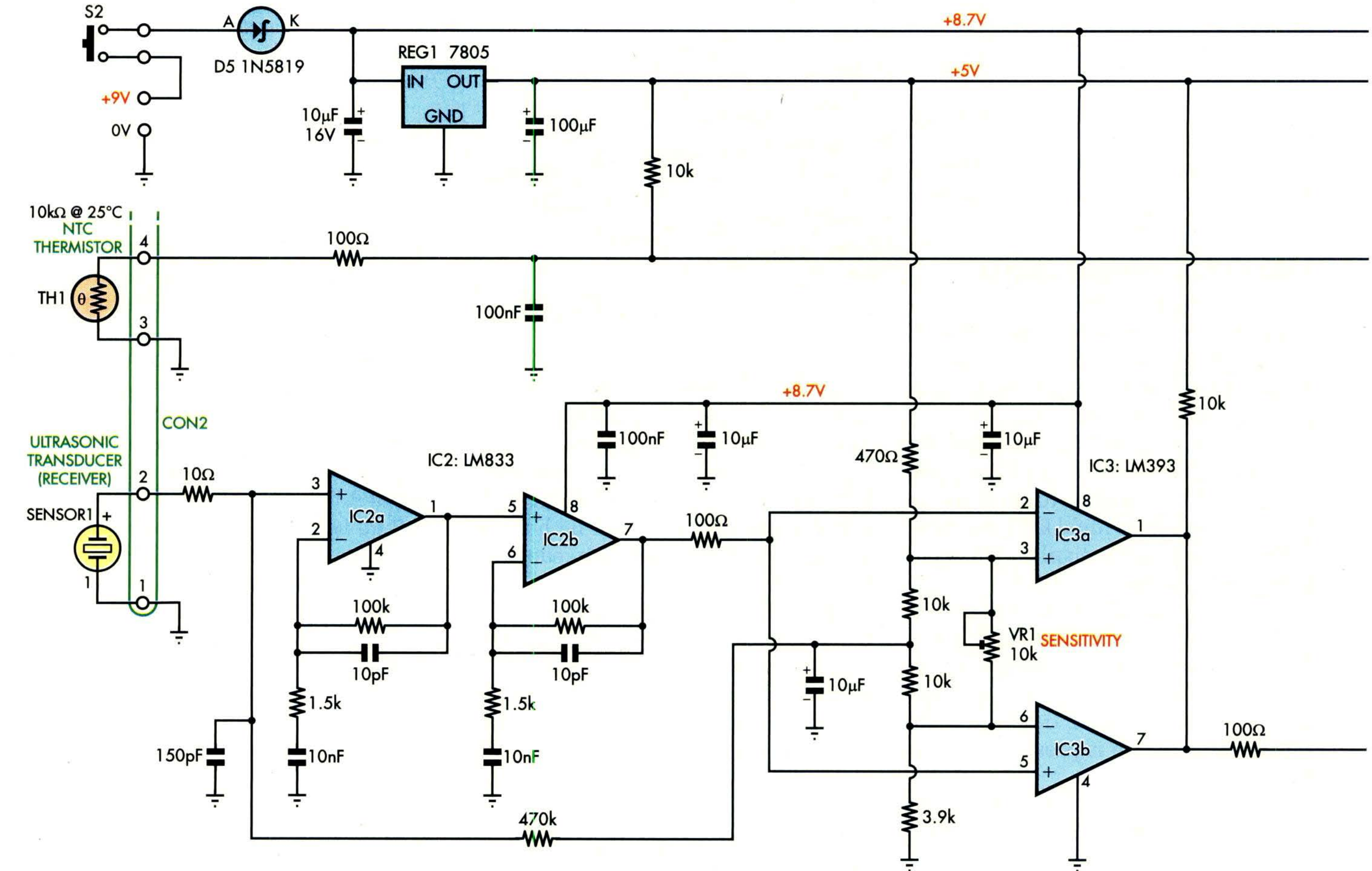
Ultrasonic signal is reflected from the water surface and is received by sensor 1, an identical ultrasonic transducer. Its signal is amplified by op amps IC2a and IC2b which are configured to provide a gain of about 67.7 each. Overall gain is therefore about 4,580 at 40kHz. Low frequency roll off is below 10.6kHz and high frequency roll off is above 159kHz. The amplifier itself also rolls off response above 100kHz.

IC2b's output is fed to a window comparator comprising IC3a & IC3b. Its sensitivity can be varied by trimpot VR1.

It only produces an output when the signal from IC2b has sufficient amplitude to exceed its positive and negative thresholds. That only happens when there is ultrasonic signal being bounced off the surface of the water in the tank. When that happens, the output at pins 1 & 7 (common collector outputs joined to-



The Water Level Gauge consists of the ultrasonic sensor assembly (above) which goes inside the tank and the processor/display (right) which is mounted outside the tank.



ULTRASONIC WATER LEVEL GAUGE

Fig.1: the circuit mainly consists of an ultrasonic receiver and amplifier (left) plus a microprocessor, display and ultrasonic transmitter (right).

gether) goes low, close to 0V. This low signal is filtered by a 3.9nF capacitor and fed to the RB3 input of IC1.

Temperature compensation

A negative temperature coefficient (NTC) thermistor (TH1) is used to measure temperature. This has a resistance of 10kΩ at 25°C and it falls with rising temperature. It is connected in series with a 10kΩ resistor to the 5V supply. The resulting voltage across the thermistor is fed to the AN5 input of IC1.

IC1 converts the thermistor voltage to a digital value, calculates the temperature and uses this to compensate for the variation in the speed of sound.

The ten LEDs are driven from separate outputs of IC1 via 470Ω resistors. Switch S1 is used allow setting the minimum and maximum water levels, when calibrating the unit.

Switch S2 is pressed when you want to read the water level. At other times the circuit is not powered and so the 9V battery should last for several years.

Some users may wish to have a permanently-on display and power the circuit from a 9V DC plugpack instead of a battery. This is quite practical and simply requires the S2 terminals to be shorted permanently.

The battery supply is regulated down to 5V with REG1. It is protected

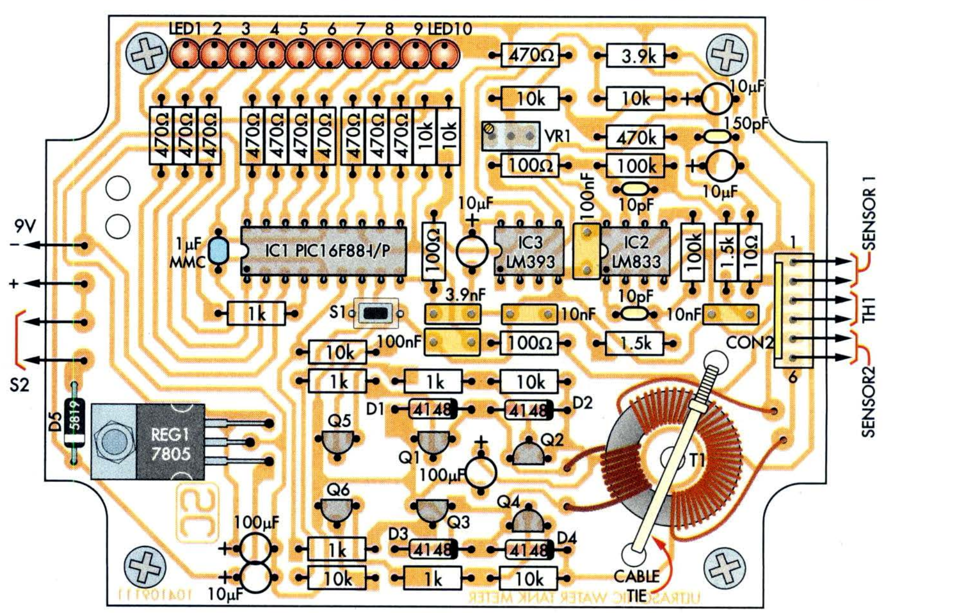
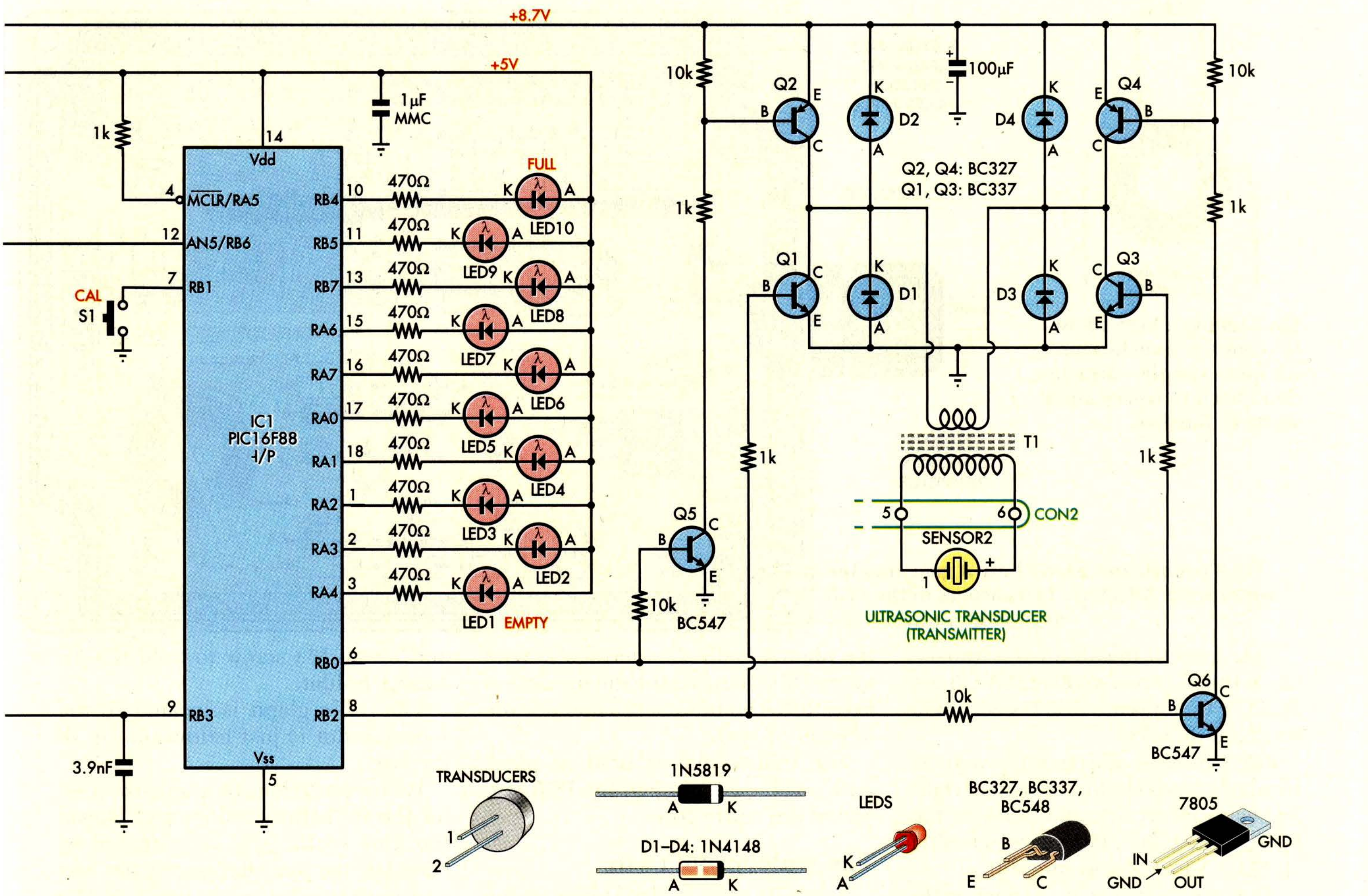
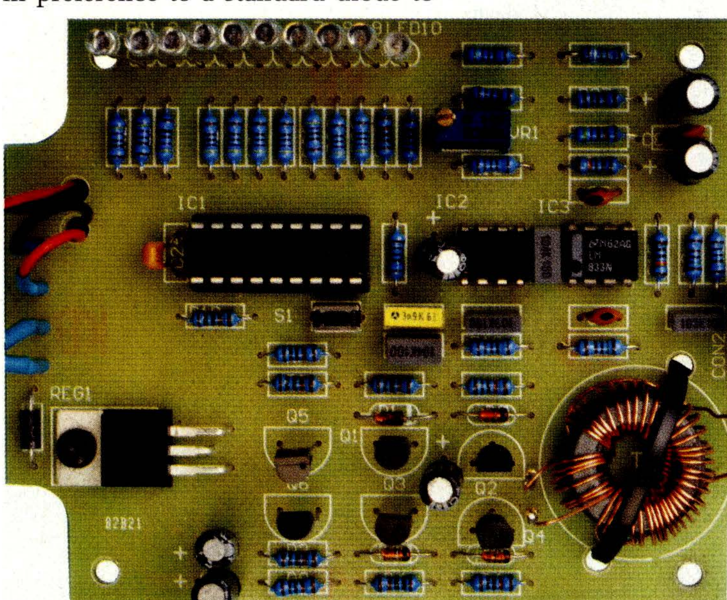


Fig.2: all components (with the obvious exception of the ultrasonic transducers and thermistor, which are in the tank) mount on one PCB.



from reverse supply connection using series Schottky diode D5. This has a low forward voltage and is used in preference to a standard diode to maximise battery life and allows the battery to drop to around 7V before it requires replacement.



The PCB, photographed here same size as the overlay at left. Between the two illustrations, assembly should be a breeze!

Construction

The Ultrasonic Water Level Gauge is constructed on a PCB coded 04109111 and measuring 104 x 78.5mm. It is mounted in an IP65 ABS box with a clear lid, measuring 115 x 90 x 55mm.

The PCB component overlay is shown in Fig.2. The PCB is shaped to the correct outline so it fits into the box.

Check that the hole sizes are correct for each component to fit neatly. The mounting holes for the regulator and the corner mounting holes are 3mm in diameter.

Install all the resistors first, checking their values with a digital multimeter. Then install the diodes, making sure they all go in with the correct polarity, followed by the PC stakes. These are located at the 9V supply, the switch (S2) terminals and for the transformer connections.

IC1 is mounted on a DIP18 socket while IC2 and IC3 can be soldered into place or you can use sockets if you wish.

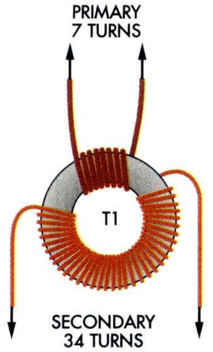


Fig.3 (above): here's how to wind the transformer. It's quite simple – and you don't need to worry about starts or finishes.

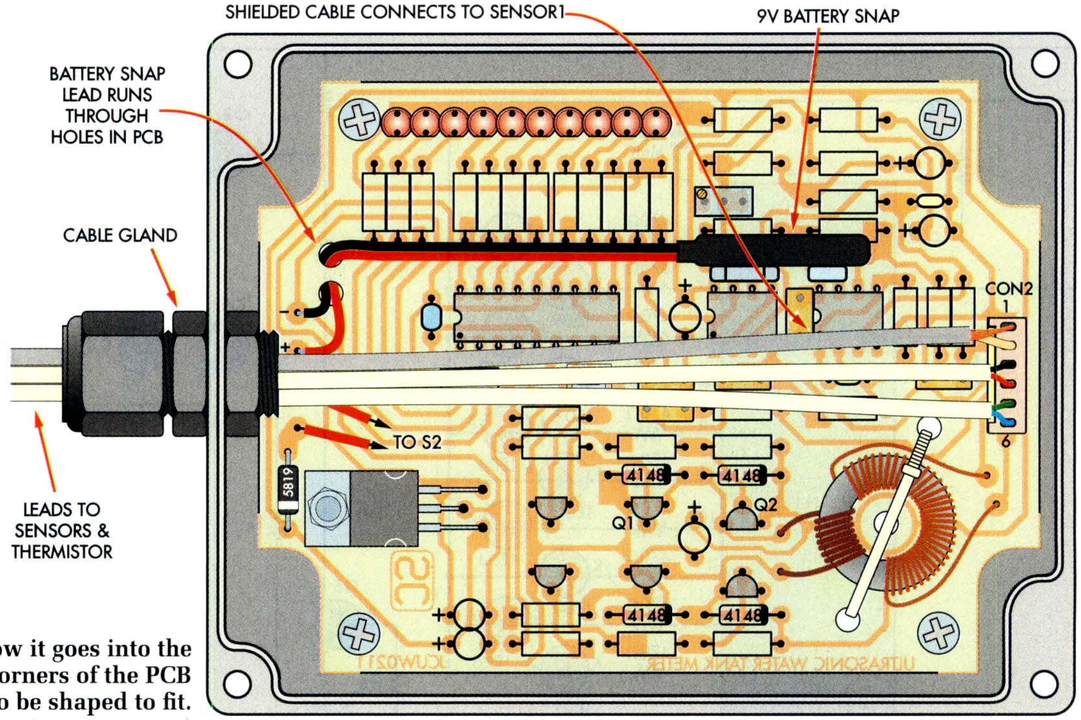


Fig.4 (right): and here's how it goes into the waterproof ABS box. The corners of the PCB need to be shaped to fit.

Take care to install all the transistor in their correct spots. Q1 & Q3 are BC337s; Q2 & Q4 are BC327s while Q5 & Q6 are BC547s.

REG1 mounts horizontally and its regulator leads should be bent at right angles to insert into the holes in the PCB. The regulator tab is secured using an M3 x 10mm screw and nut.

The capacitors can go in next, making sure that the electrolytics have the correct polarity. Note that the stripe down one side of the electrolytics indicates their negative connection.

Install trimpot VR1 with its adjustment screw to the left. Then install S1 and the 6-way header.

The LEDs should be mounted so that their tops are close to the underside of the lid, ie, with the top of each LED 25mm above the PCB.

A strip of cardboard can be used to set the height of each LED using a strip 18.5mm high that slides between the LED leads. The cardboard is then removed after soldering each LED in place. Take care with the LED orientation. The anode has the longer lead.

Winding the transformer

Transformer T1 is wound using 0.5mm diameter enamelled copper wire on a ferrite toroid.

Fig.3 shows the details: 7 turns on the primary and 34 turns on the secondary. Direction of the windings is not important.

Install the transformer as shown in the photos. Before soldering the wire to the PC stakes, scrape the insulation from the wire ends using a hobby knife or emery paper.

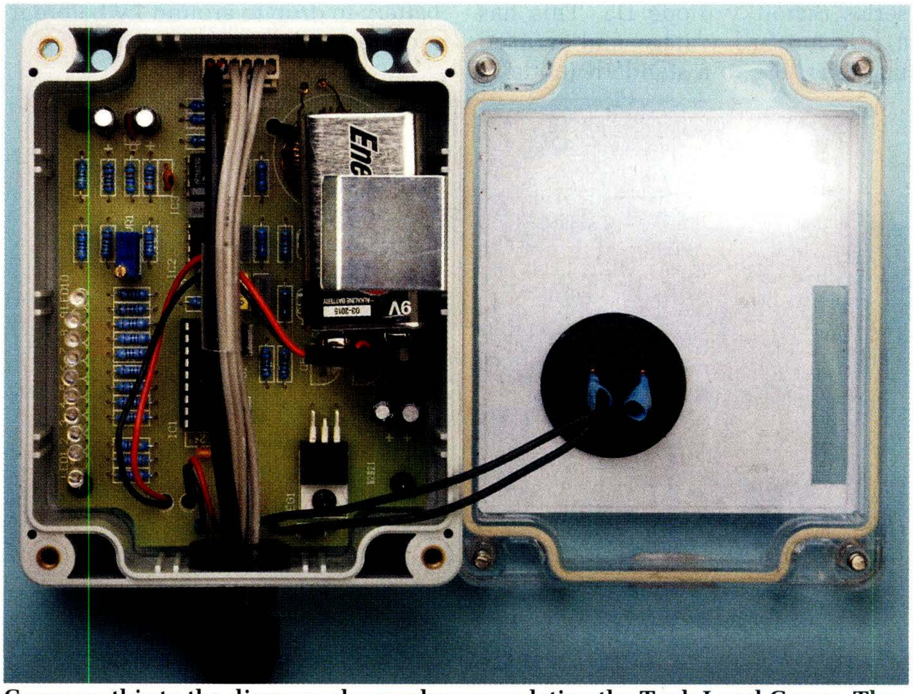
The transformer is held in place with a cable tie through the PCB and across the entire core.

The waterproof case

You will need to drill holes in the case for the switch (S2; if used) in the lid, for the IP65 cable gland at one end and for an M3 screw to hold the 9V battery holder.

The cable gland is located so the securing nut is just below the lip of the box.

We used a Nylon countersunk screw for the 9V battery holder and placed the hole so the clip was located in between the side flanges in the box and positioned over Q2 and Q4. The hole was countersunk and provides a watertight fit to the box when using a



Compare this to the diagram above when completing the Tank Level Gauge. The label can be glued to the inside of the lid. If printed on paper, a window needs to be cut (as seen above) to allow the LEDs to shine through.

Nylon screw.

If using a metal screw, silicone sealant should be used over the screw head to prevent rusting.

Wiring

Fig.4 shows the wiring details. Shielded cable is used for the wires to sensor 1 while figure-8 wire is used for the thermistor and transmitter, sensor 2.

When wiring the shielded cable to sensor 1, it is important that the shield wire connects to the negative terminal (the shorter terminal) of this sensor. The reason for this is that the negative terminal connects to the body of the sensor, to shield the transducer. The longer terminal on the sensor connects to the central wire of the shielded cable.

Wires from CON2 pass through the cable gland located on the opposite end of the case, while wires from the 9V battery clip are looped through 3mm holes in the PCB so that the wires are retained without causing stress on the connections to the 9V supply pins.

Wires to the switch are made using short lengths of hookup wire. We used heatshrink tubing over all soldered wire joints to help prevent stress (and possible breakage) of the wire connection.

As mentioned earlier, if you want a permanently-on display, simply short the S2 connections on the PCB with a length of wire soldered between the two PC stakes.

Transducer assembly

Fig.5 shows how the ultrasonic transmitter and receiver and the thermistor are mounted. The 158 x 95mm lid from a UB1 plastic box is used as a baseplate.

We used an ABS lid in preference to metal or timber because it is does not ring at 40kHz with the transmitter burst signal. Any ringing at 40kHz causes the receiver to ring for a considerable period after the 40kHz burst and will prevent measuring at close range.

Also essential to prevent signal coupling, both transmitter and receiver ultrasonic transducers are mounted within soft PVC housings and held in place with neutral cure silicone sealant.

For the transducer housings, we used the shroud (ie, outer cover) from Arlec 10A mains plugs with the top 20mm cut off. Each housing is held within a 38mm (1½") hole in the UB1 lid.

Parts List – Ultrasonic Tank Level Gauge

1 PCB coded 04109111, 104 x 78.5mm
1 IP65 box 115 x 90 x 55mm with a clear lid (Jaycar HB-6246 or equivalent)
2 Ultrasonic waterproof sensors (Jaycar AU-5550 or equivalent) (Sensor 1, Sensor 2)
1 U shaped 9V battery holder (Jaycar PH-9237, Altronics S 5050)
1 9V battery connector
1 9V 522 type Alkaline battery
1 SPST momentary 2-pin PCB switch (Jaycar SP-0611 or equivalent) (S1)
1 momentary pushbutton switch IP56 rated
(Jaycar SP-0756 or equivalent) or IP67 rated (Jaycar SP-0656 or equivalent) (S2)
1 ferrite toroid 18 x 10 x 6mm AL=700, permeability 1500
1 IP65 cable gland PG7 sized for 3-6.5mm cable
1 6-way pin header socket with 6-way pin header
1 DIP18 IC socket
1 10k NTC thermistor
5 M3 x 10mm screws
1 M3 x 6mm Nylon countersunk (CSK) screw, with nut
2m single-core shielded cable
4m light duty figure-8 wire
1m 0.5mm enamelled copper (ENCU) winding wire
1 100mm length of light duty hookup wire
1 100mm cable tie
1 100mm length of 3mm heatshrink tubing
8 PC stakes

Semiconductors
1 PIC16F88-I/P microcontroller programmed with 0410911A.hex (IC1)
1 LM833 dual op amp (IC2)
1 LM393 dual comparator (IC3)
1 7805T three terminal regulator (REG1)
4 1N4148 diodes (D1-D4)
1 1N5819 Schottky diode (D5)
2 BC337 NPN transistors (Q1,Q3)
2 BC327 PNP transistors (Q2,Q4)
2 BC547 NPN transistors (Q5,Q6)
10 3mm high intensity red LEDs (LED1-LED10)

Capacitors
2 100µF 16V PC electrolytic
4 10µF 16V PC electrolytic
1 1µF monolithic ceramic
2 100nF MKT polyester
2 10nF MKT polyester
1 3.9nF MKT polyester
1 150pF ceramic
2 10pF ceramic

Resistors (0.25W, 1%)

1 470kΩ	2 100kΩ	8 10kΩ	1 3.9kΩ	2 1.5kΩ
5 1kΩ	11 470Ω	3 100Ω	1 10Ω	

1 10kΩ top adjust multiturn trimpot (VR1)

Ultrasonic transducer mounting hardware
1 UB1 ABS box lid 158 x 95mm
2 140 x 15 x 1mm aluminium as mounting brackets
4 M3 x 10 Nylon screws with M3 nylon nuts or tapped Nylon spacers
1 IP65 cable gland PG7 sized for 3-6.5mm cable
2 10A mains plugs with clear covers (eg Arlec Type 9331B)
2 rubber grommets suitable for a mounting hole of 9.5mm and cable 6mm
1 P-type Nylon cable clamp for 5mm cable
1 M4 x 10mm Nylon screw
1 M4 Nylon nut
"Food grade" silicone sealant (eg neutral cure roof and guttering)

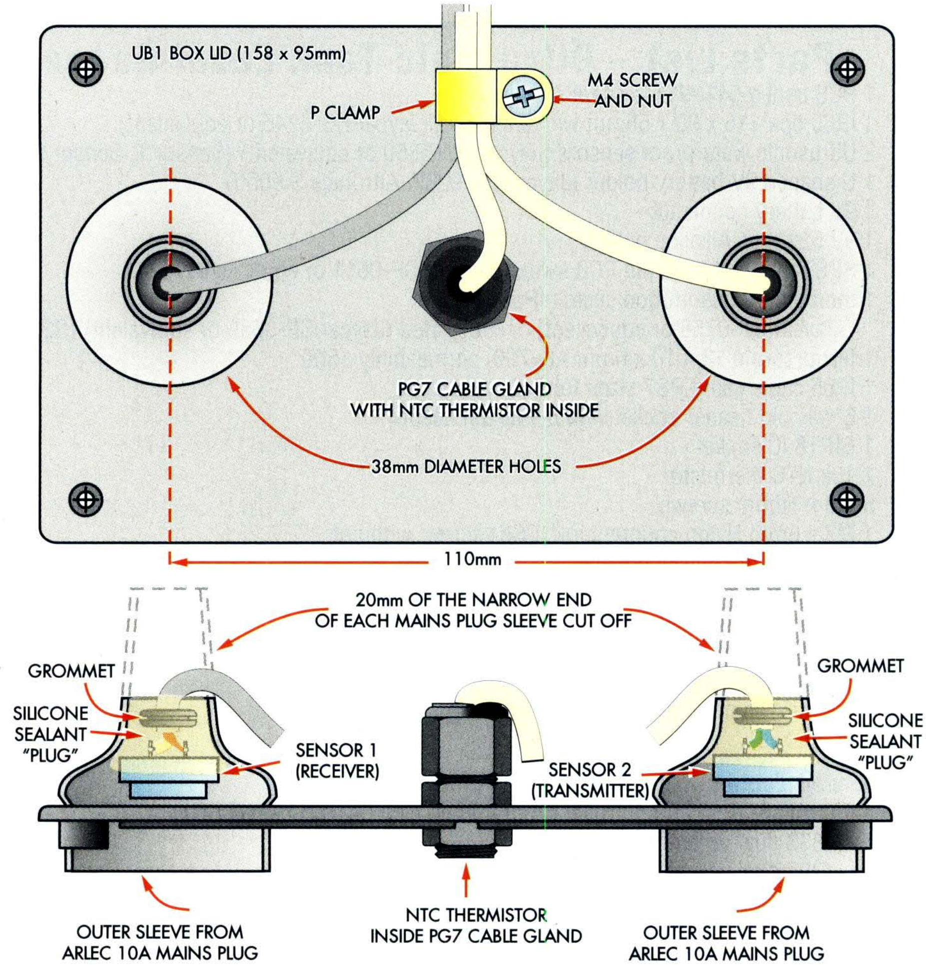


Fig.5: detail of the ultrasonic transducer and thermistor mounting in the lid from a UB1 zippy box (the rest of the box is not used).

It is important that both transducers are held parallel to the face of the "shroud" while the silicone sealant cures. We did this by placing a stack of seven 10c coins over each sensor, as shown in the photograph. These allowed us to align the top of the stack with the face. Make sure you don't glue any of the coins to the sensors!

For the sensor assembly mounting, drill out the two 38mm holes in the zippy box lid 110mm apart. A 1½" hole saw can be used for this. A 12mm (1/2") hole is also drilled out for the PG7 gland in the centre of the lid while a 4mm (5/32") hole is drilled for the P-clamp screw (as shown in Fig.5).

Pass the thermistor wires through the top of the gland and strip back the insulation from both leads ready for soldering to the thermistor.

The thermistor leads should be cut to 10mm before soldering to the wires. Slide a short length of 3mm heatshrink tubing over the wire ends and shrink down with a hot air gun. This tubing will prevent the thermistor leads shorting together.

The thermistor is positioned within the cable gland and secured by tightening it. The thermistor can be sealed within the gland with neutral cure silicone sealant.

Testing

With IC1 out of its socket, apply power and check that there is 5V (4.85 to 5.15V) between the pins 5 and 14 of IC1's socket. Check that IC2 and IC3 have about 8.7V between pins 4 and 8 when there is a 9V supply connected to the input. Check that the bias voltage between pin 7 and pin 4 of IC2 is between 3.3 and 3.8V.

If all checks out OK, disconnect power and insert IC1 taking care to orient it correctly. Check that at least one LED lights when power is applied (ie, S2 is pushed).

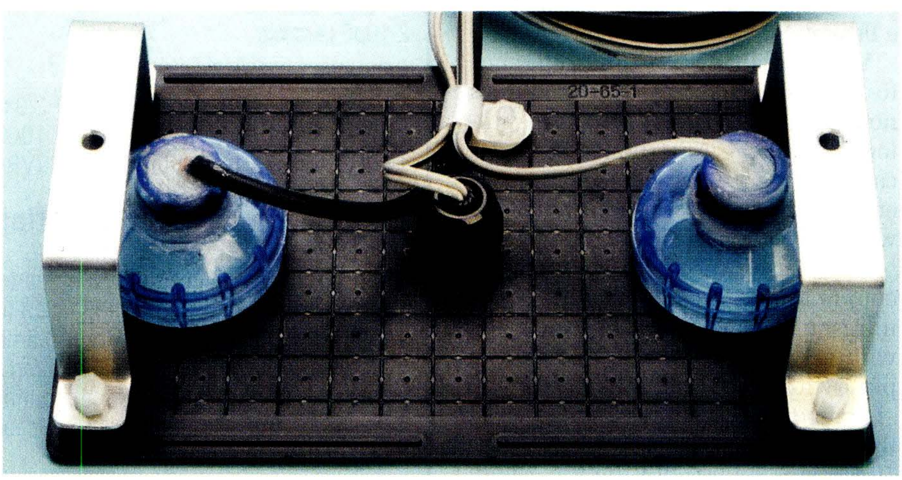
Adjust VR1 fully anticlockwise. This sets the sensitivity to detection of received ultrasonic signal at maximum and any noise or direct coupled signal will be detected. This will be indicated with the full LED lit.

The default calibration is set for 331mm for the minimum measurement and 1m for the maximum measurement. Aim the transducer assembly square-on to a hard surface such as a timber floor, wall or window at a distance of about 1m.

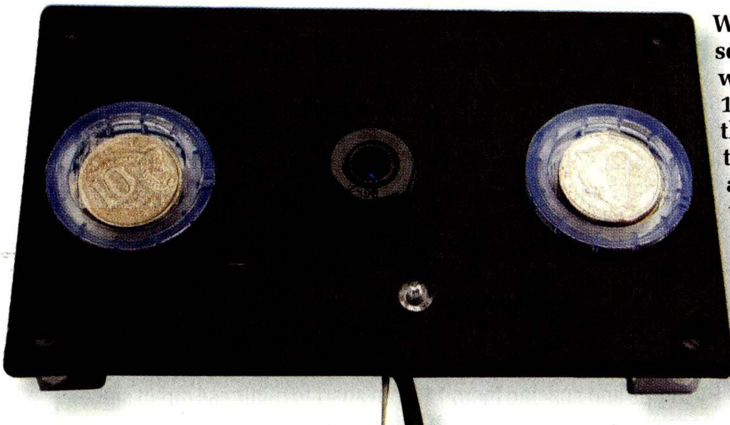
Adjust VR1 slowly clockwise until either the empty LED, or any lower LED lights. Moving the transducer assembly should now allow a measurement over 340mm to 1m with the LED display showing the range.

Note that the measurement update is every 0.5s so movement of the sensors needs to be done slowly if all the 19 levels are to be indicated. You may need to wind VR1 further clockwise if the full LED sometimes lights with distances above 340mm.

If VR1 is wound too far clockwise, the sensitivity is reduced so that reflected signal may never be detected. The display will cycle through lighting LED1 through to LED10 in sequence to indicate that no measurement of



The transducer (sensor) mounting assembly, ready for installation inside the tank. The aluminium brackets suited our tank, yours may well be different!



While the silicone sealant was drying we used a stack of 10c coins on top of the sensors to check they were both absolutely level with the "lid" surface. You can just see the (blue) nose of the thermistor poking through the cable gland (centre of pic).

distance is made.

With a constant distance measurement the measurement update rate goes from once every 0.5s to once every 25s after running for 2 minutes.

This is something to be aware of as you may initially think there is a fault if the display does not change with a changed distance.

To have the display update return to the faster 0.5s update, switch off power for a few seconds. At power up, the display update returns to the faster rate. The faster rate is also restored if S1 is pressed for calibration.

Dot or Bar?

The initial default display is for the dot mode. This has 19 levels shown with the intermediate levels indicated with two adjacent LEDs lit.

If you want a bar display (with only 10 levels) this can be selected by switching off power and pressing and holding switch S1.

Power up again and the row of LEDs from LED1 to LED5 will light (indicating bar mode) while the switch is held pressed. When the switch is released, the measurements will show as a bar.

This setting will remain unless you reset to the dot mode, using the same method with S1 pressed at power up.

When returning to the dot mode, just LED6 on its own will light (indicating dot mode) while S1 is pressed and upon release of the switch, the dot mode will be displayed.

Setting the bar mode is not recommended for battery operation since this draws extra power due to more LEDs being normally lit.

The bar mode is recommended if night-time level measurements are required and when the power for the Water Tank Level Gauge is from a 9VDC plugpack. The bar mode readily shows the level at night whereas a dot display showing just one or two LEDs does not show the actual position within the 10-LED bargraph as clearly as the bar mode.

Calibration

Calibrating is done once the location of the ultrasonic transducer assembly has been decided (more details on the location for the sensors are in the installation section).

Two calibrations need to be made, one for the distance between the transducer assembly and the water level of a full tank and the second the distance between the transducer assembly and the level of an empty tank.

You do not need to empty or fill the tank to do these calibrations.

You should be able to determine both the full and empty level of your tank knowing where the heights of the overflow (full) and outlet (empty) pipes are located.

Measure the vertical distance between where the ultrasonic transducer assembly will be located to the bottom of the overflow pipe to obtain the full level. Then measure the vertical distance from the ultrasonic transducer assembly to the bottom of the outlet pipe to obtain the empty level.

Calibration can be done using these distances and aiming the ultrasonic transducer assembly at a hard surface, such as a wall.

It might be easier when doing this to short out the S2 switch so that the Water Tank Level Gauge runs without holding the switch closed.

To calibrate the full level, aim the ultrasonic transducer assembly square on (perpendicular) to the wall at the full distance between the transducer assembly and the wall.

Now press switch S1. Either the empty or full LED will flash. If the empty LED is flashing skip this paragraph and go to the next paragraph. If the full LED is flashing, keep the switch closed and maintain the distance steady between the sensors and the wall.

After eight flashes the LED will stay lit for about two seconds and then go out. The full calibration is now set.

If the empty LED is flashing, release S1 and then repress it and wait till the full LED begins to flash. After eight flashes the LED will stay lit for about two seconds and then go out. The full calibration is now set.

To calibrate the empty level, aim the ultrasonic transducer assembly square on (perpendicular) to the wall at the empty distance.

Now press switch S1. Either the empty or full LED will flash on and off.

Temperature Compensation

While the water in the tank tends to remain at a relatively constant temperature over a period, this is not the case for the air space within a water tank. With full sun on the tank, this temperature can rise to over 50 degrees C during the day only to plummet during the night. The variation in air temperature means that we need to correct for the change in the variation in the speed of sound, to maintain accurate water level readings.

The speed of sound at 0°C is 331.3m/s while at 50°C it is 363.13m/s. These values are calculated from the formula:

$$\text{Speed of sound} = 331.3 \times \sqrt{1 + \frac{°C}{273.15}}$$

Using that formula we calculate that over the range of 0 degrees C to 55 degrees C, the speed of sound will vary by 9.61%. That can cause a reading inaccuracy of two levels in the 19-level display.

Note that we do not need to compensate for the change in the speed of sound due to variations in humidity or air pressure. Even with a change in humidity from zero to 100%, the speed of sound only changes by 1.2%, not enough to affect the reading of this tank level gauge.

More information about the speed of sound is available in the Audio Engineering Society paper. Vol. 36, No. 4, April 1988 entitled "Environmental Effects on the Speed of Sound" by Dennis A Bohn, (Rane Corporation, Mukilteo, WA 98275 USA). This is available at www.rane.com/pdf/ranenotes/Enviromental%20Effects%20on%20the%20Speed%20of%20Sound.pdf

Information is also at http://en.wikipedia.org/wiki/Speed_of_sound

How we minimised the minimum distance measurement

The ultrasonic transducers in this project can be used for transmitting, receiving or for both. So the same transducer could be used to transmit a 40kHz burst and then it could be used to receive the reflected signal. This would be ideal because it would save having a separate receive transducer.

But there is a problem with using the transmit transducer to also receive the reflected signal. That is, the transducer continues to "ring" at 40kHz signal for about two milliseconds after any drive signal has ceased. (Even if you have a separate receiver it also "rings" if an ultrasonic transmitter is placed too close to it).

With sound travelling at a speed of 340m/s the ultrasonic burst will have travelled 680mm in that 2ms period. This means that the minimum distance that can be measured is around 340mm. That's hardly ideal since it means that you could not measure the water level in a tank that is full.

We got around that problem by having good isolation between the transmitter and receiver transducers. Such isolation prevents the receiver from resonating after the transmitter is driven by a 40kHz burst. In that way the receive transducer is ready to receive reflected ultrasonic signal almost immediately the transmit burst is completed.

This was achieved by mounting the transducers in separate soft PVC cups and spacing them 110mm apart to minimise direct signal reaching the receiver through the mounting surface.

If the full LED is flashing skip this and go to the next paragraph.

If the empty LED is flashing, keep the switch closed and maintain the distance steady between the sensors and the wall. After eight flashes the LED will stay lit for about two seconds and then go out. The empty calibration is now set.

If the full LED is flashing, release S1 and then repress it and wait till the empty LED begins to flash. After eight flashes the LED will stay lit for about two seconds and then go out. The empty calibration is now set.

Note that an error will occur if the full and empty calibration distances are reversed. LED1 and LED10 will flash alternately to indicate this. The calibration can be redone using the correct full and empty distances.

If the calibration appears to be stuck and continues showing an error after recalibration, you can return to the default calibration settings. Shorting the thermistor terminals at CON2 and pressing switch S1 returns the default settings.

Both LED1 and LED10 will light for 1s as an acknowledgment of the default settings. The display will then operate between 331mm minimum and 1m maximum and have a dot display as the default.

Calibration can then be redone to set the minimum and maximum levels.

Installation

The ultrasonic transducer assembly preferably needs to be mounted inside the water tank within the top most airspace. There should be sufficient space for this in the dome shape of the tank roof.

Steel tanks generally have a flat roof and will need a different mounting scheme. The transducer assembly should not be placed too close to the side of the tank or the receiver may detect signal reflected off the side.

Our gauge, for example, needed the transducer assembly to be 110mm away from the side of the tank.

Check that the Water Tank Level Gauge works without false sensing before making a permanent installation.

The transducer assembly is mounted within the tank using suitable brackets attached to the roof of the tank. For a plastic tank you can attach the brackets to the tank roof with screws and nuts and holes drilled through the tank roof. For a concrete tank, glue the assembly to the roof with builders' adhesive or neutral cure silicone sealant.

"Food grade" sealant should be used where the tank is used for drinking water. Food grade silicone is usually neutral-cure plumbers roof and gutter sealant (eg, Zbond roof and gutter sealant, Kason food service Silicone Adhesive Sealant, Selleys Silicone 401 etc). Check the label to see if it is suitable for this purpose.

Ensure that the transducer faces are positioned parallel to the water surface otherwise the reception of reflected ultrasonic signal may be too weak for reliable detection.

The advantage of using aluminium brackets is that these can be carefully bent to align the sensors correctly with the water surface. Note that a water tank may not be located on a perfectly horizontal ground base, so do not use the tank as a guide to positioning the sensors parallel to the water surface.

A spirit level can be used to check sensor placement to ensure they are horizontal and parallel to the water surface.

If wires from the transducer assembly are to exit from the tank, use a cable gland or via a silicone covered hole. It is important to ensure the tank is kept mosquito proof.

The Water Tank Level Gauge can be installed directly onto the outside of the tank or onto a nearby wall.

Specifications

Power .... 7.5 to 9VDC at 18 to 24mA max for dot mode, 80mA max for bar mode

Display .... Dot or Bar with 19 levels in dot mode, 10 levels for bar mode

Reading update .... Initially every 500ms increasing to every 25s after 2 minutes. Returns to 500ms update with a display value change, no signal received and during calibration

Temp compensation .... Speed of sound compensated between 0-70°C

Measurement distance .... Minimum 40mm; Maximum 2.4m

Ultrasonic burst .... 15 cycles at 40kHz (375µs)

Transmitter drive .... 85Vpk-pk with a 9V supply

Note that the box has four mounting points that are outside the box's sealed section but can only be accessed by removing the lid of the box. Mounting can be on brackets or directly onto a wall or the tank.

It is not recommended to drill holes anywhere in a concrete tank or it may crack. Plastic and steel tanks can have mounting holes drilled in the top cover but not on the sides where the water sits. Plastic tanks generally have lifting attachment points and you can drill into these sections or use the existing lifting hole for mounting.

To mount the Water Tank Level Gauge to the side of the tank, secure two lengths of 25mm x 25mm hardwood spaced apart to match the box's mounting holes. The timber can be secured to the tank sides with builders adhesive or silicone sealant. The box is then attached to the timber batons with suitable wood screws.

Make sure the Neoprene seal is inserted around the lid before the lid is attached to the box base.

Steel tanks

Steel tanks are not so easily accommodated because they usually have a flat roof and allow the water to fill up to this roof leaving no room to mount the sensors within the tank.

Additionally, the metal tank is liable to resonate at the 40kHz ultrasonic frequency causing the receiving sensor to ring and prevent the 40mm minimum distance measurement from working.

You could have the transducer assembly mounted within the inlet strainer. Alternatively, the PVC shrouds, which encapsulate the ultrasonic sensors, could be inserted into holes in the tank roof.

The transducer assembly should not be directly mounted onto a steel tank; use rubber grommets or dobs of silicone sealant at each corner. This provides a compliant mounting which prevents the steel roof from resonating at 40kHz.

If the transducer assembly is mounted above the tank it could be covered using the box that came with the UBI box lid. The wires could exit through a cable gland located in the side of the box.

Some silicone sealant around the seal will prevent any water entering the box although rainwater onto the assembly will not cause a problem so long as it can escape out the bottom of the box.

Another method for using the Water Tank Level Gauge with steel tanks is to use a different mounting method for the ultrasonic sensors where they are located onto a smaller diameter "plate" that is installed within a length of 90mm PVC pipe that protrudes by 331mm above the tank.

The default minimum calibration (full tank level) of 331mm is used and the maximum distance (empty tank level) calibration can be changed from the 1m setting to be up to 2.4m to suit the tank depth. This depth includes the 331mm extension above the tank.

Note that the default full tank level must be used rather than setting a new 331mm full tank level because the default setting ignores all received signal for the first 331mm.

A recalibrated 331mm distance will have the metering looking for reflected sounds after a 40mm distance and will cause false readings when reflected signal comes directly back from the pipe. So if the full tank level has been recalibrated, then the default values must first be restored.

Shorting the thermistor connections and pressing S1 for a few seconds does that. Using the default full tank level means reflected sounds from the sides of the PVC tubing will be ignored. Only the empty tank level should be recalibrated to suit the tank depth. SC

Improved stability for the GPS-Based Frequency Reference

By JIM ROWE

Did you build the GPS-based Frequency Reference described in the March-May 2007 issues of SILICON CHIP? Its frequency stability can be significantly improved with a couple of circuit changes, as described here. The modifications also make it easier to lock the oven crystal to the correct frequency.

READERS WHO BUILT the GPS-Based Frequency Reference described in the March, April and May 2007 issues of SILICON CHIP may recall that in the third article we described some circuit changes to improve its short-term stability. These modifications were made in response to an email which had arrived from New Zealand reader Dr Bruce Griffiths, advising that the original method used for cascading the synchronous frequency dividers IC4, IC5 & IC6 was not the best way.

When these changes were made, it did appear that the performance of the Frequency Reference had been improved. However, recent testing has shown that there is a better way to cascade the synchronous divider chain. It appears that the earlier changes created subtle problems in terms of divider instability – and as a result it was much easier than it should have been to set the Reference to "lock" onto a frequency other than the correct 10.000000MHz.

This became evident recently after quite a few hours were spent in testing the prototype of the GPS-Based Frequency Reference, with an equipment set-up which had the necessary measurement accuracy.

The main cause of divider instability turned out to be the way the "terminal count" output of the top decade divider IC4 (pin 15) was coupled to the "count enable carry" or CET input of IC5 (pin 10) in the next divider stage, instead of the "count enable" input of that chip (pin 7). From my reading of the 74HC160 device data back in 2007, it had seemed that this was the correct choice. However, recent testing showed that with this configuration there was a tendency for IC5 to be occasionally clocked on the ninth pulse from IC4, instead of the correct tenth pulse.

As a result, there was a significant "jitter" in the nominal 100kHz output from IC5, as it effectively danced between frequencies varying between 100kHz and 111kHz.

After trying various circuit changes, a cure was found by swapping the connections to the CET and CEP inputs of IC5 – feeding the TC output of IC4 to the CEP input (pin 7) and connecting the CET input (pin 10) to +5V. IC4 and IC5 now divide down the crystal oscillator frequency by the correct factor of 100, with rock-steady reliability.

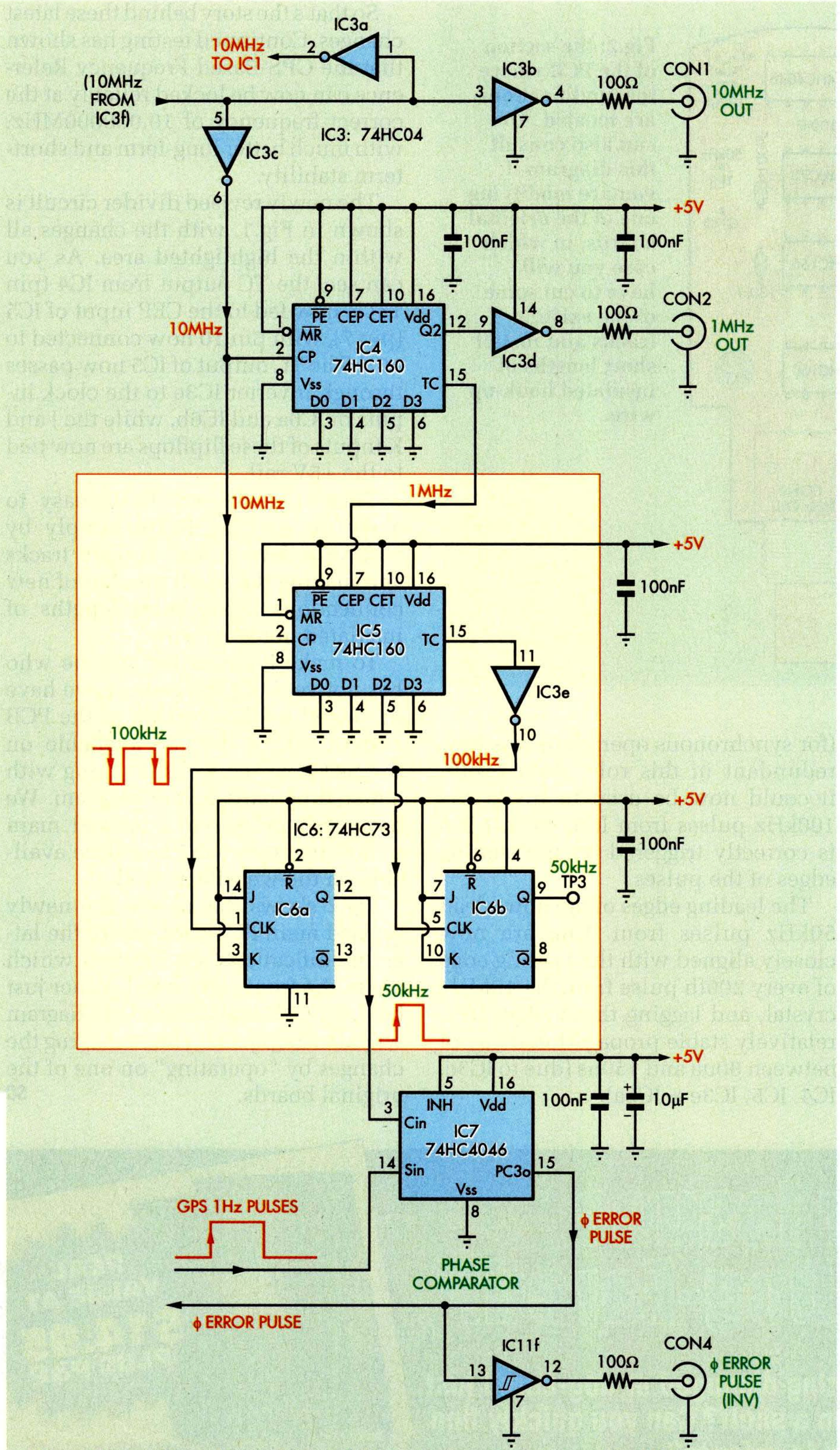


Fig.1: the revised divider circuit (all changes inside the highlighted area). IC4's TC output (pin 15) is now fed to IC5's CEP input (pin 7), while pin 10 now goes to +5V. IC5's TC output is fed via IC3e to the clock inputs of IC6a & IC6b, while the J & K inputs of these flipflops are now tied to the +5V rail.

This revealed that there was another configuration error in the original circuit changes to convert the third divider stage (using IC6) to fully synchronous operation. The method chosen did work but had an unintended side effect: the output pulses of IC6a fed to the phase comparator IC7 were

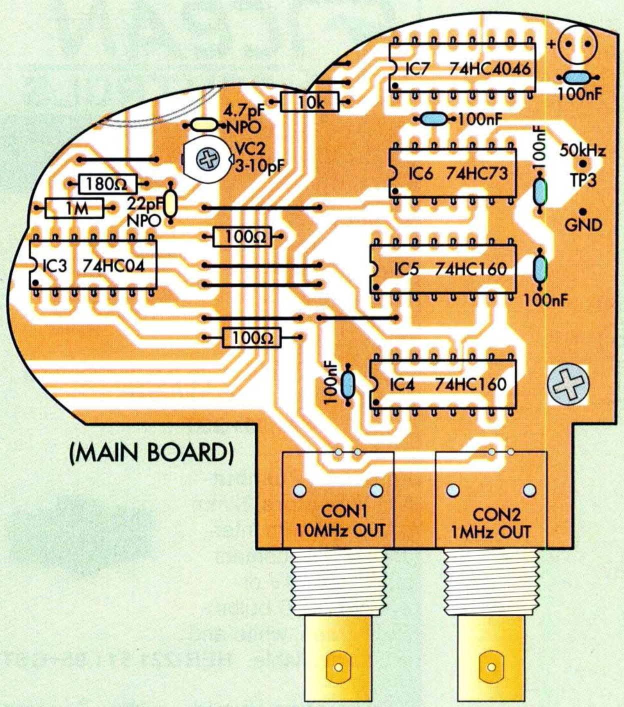


Fig.2: the section of the PCB where the modifications are located. You can also consult this diagram if you are modifying one of the original boards, in which case you will have to cut some of the existing tracks and install short lengths of insulated hook-up wire.

not the correct 50kHz pulses but were actually bursts of 5MHz pulses within the 50kHz pulse envelopes.

As a result, it was possible for the phase comparator to allow the overall frequency control loop to lock at a number of closely spaced different frequencies – only one of them being the correct 10.0MHz.

Restoring IC6 to its original "non-synchronous" configuration fixed this problem completely. Inverter IC3e which had been used to invert the 10MHz clock signals being fed to IC6 (for synchronous operation) was now redundant in this role, As a result, it could now be used to invert the 100kHz pulses from IC5, so that IC6 is correctly triggered on the leading edges of the pulses.

The leading edges of the now-clean 50kHz pulses from IC6a are now closely aligned with the leading edge of every 200th pulse from the 10MHz crystal, and lagging those edges by a relatively stable propagation delay of between 80na and 150ns (due to IC3c, IC4, IC5, IC3e & IC6a).

So that's the story behind these latest changes. Continued testing has shown that the GPS-Based Frequency Reference can now be locked reliably at the correct frequency of 10.000000MHz, with much better long-term and short-term stability.

The newly revised divider circuit is shown in Fig.1, with the changes all within the highlighted area. As you can see, the TC output from IC4 (pin 15) is now fed to the CEP input of IC5 (pin 7), with pin 10 now connected to +5V. The TC output of IC5 now passes through inverter IC3e to the clock inputs of IC6a and IC6b, while the J and K inputs of these flipflops are now tied to the +5V rail.

These changes are fairly easy to make on existing PCBs, simply by cutting a few of the copper tracks and making the small number of new connections using short lengths of insulated hook-up wire.

To make it easier for anyone who has not yet built the project, we have produced a Mk.3 version of the PCB pattern which will be available on the Silicon Chip website, along with a matching parts layout diagram. We have also produced a revised main circuit diagram, which will be available on the website as well.

Fig.2 shows the area in the newly revised main PC board where the latest modifications are located, which are in the front right-hand corner just behind CON1 and CON2. This diagram will also help you if you're making the changes by "operating" on one of the original boards. **SC**

SERVICEMAN'S LOG

Dave Thompson*

It's very simple – when you know how!

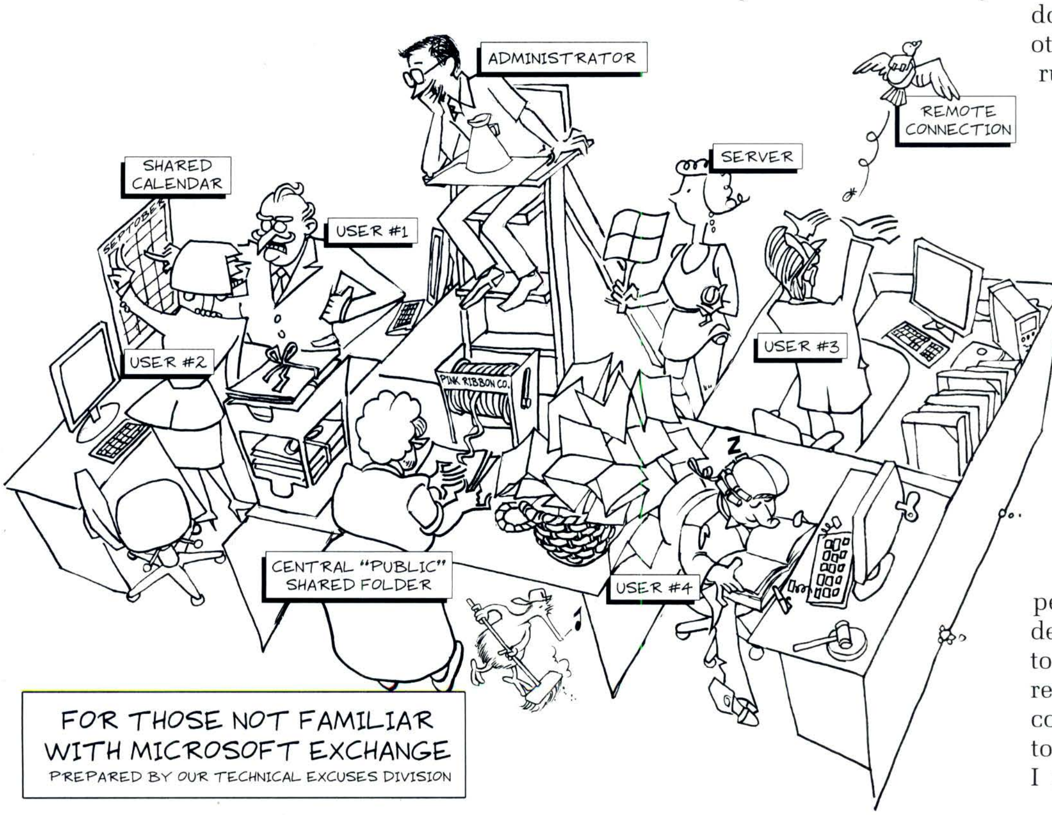
It's amazing how something that's relatively trivial can cause big problems. Of course, all problems are simple once you know what the answer is but they can be stressful in the meantime.

In this profession, our lives are based around problem solving. However, every now and then we strike a problem that has us struggling to find a solution.

One such problem occurred recently when a major client looked at implementing a new Microsoft Exchange server system. They wanted to be able to work remotely, centralise their data storage, allow others in the office to answer each others' emails and view and edit each others' shared calendars and "to-do" lists. And since everyone already used the latest version of Microsoft Outlook, it made sense for them to look at Exchange, which ticks all the boxes.

For those not familiar with Microsoft Exchange, it is a network communications and sharing hub that's typically installed on a Windows Server system. Setting up and configuring an Exchange system is not for the faint-hearted though and many a technician has lost a lot of hair trying to get things working.

In this case, these guys wanted a whole new office system and gave me the job of implementing it. I told them that it wouldn't be cheap. Exchange by itself is quite expensive, although it can be sourced at a more reasonable price when bundled with some versions of Windows Server. And so that was the way I recommended they go. Being a group of legal professionals, expense wasn't a big issue for them but I didn't want to throw their money away.



FOR THOSE NOT FAMILIAR WITH MICROSOFT EXCHANGE
PREPARED BY OUR TECHNICAL EXCUSES DIVISION

For their situation, I went with Microsoft Small Business Server 2008 with Exchange 2007 and five Client Access Licenses (CALs), all for a run-out, knock-down price of NZ$1500.00. There are four users in their office, plus an administrator (me), which tidily made up the five users. If they expand, more CALs can be purchased as necessary, to allow more users.

I duly built a server box, installed all the relevant bits and pieces and got it up and running. As a result, they now had a central "public" shared folder system which they could all access from anywhere and add client files. Of course, we don't need some fancy server system to do this simple task; instead, the real magic happens with Exchange. This powerful tool allows everyone in the office to securely share their calendars, contacts, tasks and to-do lists, as well as email in-boxes and other items necessary for the efficient running of the office.

With this system in place, anyone can easily deal with someone else's emails and appointments without leaving their own desk. And if they are out of the office (in this case the partners work from home one day a week), they can simply log into the Exchange system using any web browser and then access everything as if they were on site.

However, one point of interest here is that while the remote system works using other browsers such as Opera or Firefox, some functions do not render properly unless Internet Explorer is used.

Now I can already hear some people arguing that a simple remote desktop connection is all that's needed to achieve similar results. That's correct to a point but no other system I could envisage would do everything to the level they required. In fact, I initially offered two other (much

cheaper) alternatives, both of which were rejected because they didn't quite make the grade. What's more, I didn't even consider Linux-based or open source solutions as I have no in-depth experience with Linux and learning on a job like this is neither professional nor feasible.

Once everything was up and running, everyone was amazed at what they could do with the system. They were impressed with how simple it was to use and because they weren't overly computer literate, everything had to be as turn-key as possible.

Unfortunately though, a brain-bender problem cropped up when they wanted to access emails and appointments on their Samsung Galaxy smartphones. I've got to admit that I'm no phone guru either but I didn't think that this would be a problem, simply because Exchange has embedded mobile device support and most smartphones boast auto-configured Exchange server set-ups.

However, try as I might, I couldn't get the phones to connect to the server. In each case, the phone's set-up wizard would go through to the point of checking the settings but would then throw up an unhelpful error saying that the set-up could not be completed.

I tried everything I could think of, including connecting via WiFi, Bluetooth and even direct cable but they just wouldn't connect. Finally, after a few days of frustrating effort, a visitor offered me an iPhone which worked with his Exchange server to see if I could connect it to our system.

Encouraged by this, I went through the set-up on the iPhone. This went smoothly until it eventually threw up a message stating that the security certificate was not verified and asking if I wanted to continue. This did not happen with the Galaxy phones.

Finally, it all clicked. When the server is set up, a local security certificate is created. In order for client computers to connect, either a security exception must be added via the Control Panel/Internet Options dialog or the certificate must be installed on those machines. The Galaxy phones were gagging because the certificate wasn't present and where the iPhone gave an option to continue without it, the Galaxy phones just tanked with an error.

The cure was very simple. Once each phone was connected to the computer, the certificate could be installed and the set-up then went through as expected. Chalk that one up to inexperience in my part!

It is often the small things like this that can blow a job's budget or make life very stressful for a serviceman. If I hadn't tried the iPhone who knows how long it might have taken before I concluded that it was a certificate error?

Fantasy vs reality

Social gatherings can be something of an occupational hazard for those of us in the servicing industry. Inevitably, once my occupation becomes known, someone raises a computer problem and expects a resolution then and there.

Many people seem to assume that computer repairs are easy and that most problems can be magically fixed with just a few well-chosen words of wisdom or, in severe cases, just a key press or two. Because we don't have grease up to our elbows or wear dirt-smeared overalls, our work apparently is of little value.

When I was much younger, I wanted to be an aircraft engineer, imagining myself walking around in a spotless white coat and travelling to exotic ports to swap out a flange-valve regulator (or some such) on the Concorde. And then of course, there would be all those hostesses who would admire me for my incredible skills!

In reality, my early years as an avionics apprentice were spent scrubbing charred clumps of dead birds from engines, fetching striped paint and left-handed screwdrivers from stores, and fighting claustrophobia while stuffed

Items Covered This Month

- Microsoft Exchange installation
- Fantasy vs reality
- A simple fix for a lawnmower
- Black & Decker leaf blower repair

**Dave Thompson, runs PC Anytime in Christchurch, NZ.*

into impossibly small wing tanks to check wiring looms. Trips overseas to deliver aircraft were filled years in advance and the likelihood I would go on one in my lifetime was about the same as winning first division Lotto three weeks in a row!

Likewise, the first thing I tell starry-eyed work-experience students at my computer-repair workshop is that they can forget their fantasy of playing "Counter Strike" all day long in a clean room on the latest and greatest computer hardware. The truth is, computer repair (and in fact any appliance repair) can be dirty, dusty, occasionally frustrating and often stressful.

We usually don't see the latest and greatest hardware unless someone wants an over-the-top machine built or repaired. Instead, most of our work is done on one to 8-year old clunkers complete with spider webs, mouse droppings and a couple of centimetres of dust over everything.

Many people only come to us as a last resort, usually after family and friends have "had a go at it", and they are often grumpy. And even though they've put up with their particular problem for months, they now need it fixed "by this afternoon".

On top of that, many think they don't have to spend much money on anything as simple as computer repairs. It's not uncommon to hear comments such as "I don't think it's anything very serious" (how would they know?) and "no doubt you guys will have this done in a few minutes"!

And then there's that old chestnut: "my friend/brother-in-law/cousin/workmate, who knows all about computers, reckons it is the [insert anything you like here] and said it should only cost [insert impossibly low price here] to fix".

These comments are all designed to apply psychological pressure on us. It's the customer's way of letting us know that they expect the repairs to be done immediately for next to nothing and if we charge more than they consider a fair price, they'll complain bitterly about it. After all, music, movies and software can be found free on the Internet and since it doesn't appear to take long or involve much physical effort to fix a computer, it follows that any repairs should also be really cheap.

The "curse" of the serviceman is that we deal in knowledge and experience, intangible commodities that some people have a really tough time accepting have any value and thus cost money. A plumber can charge $200 just to turn up after hours but if a computer technician dares charge that much to come out and resolve a problem, watch out!

Of course, I'm making it sound worse than it really is and unrealistic clients are thankfully few and far between. However, it no longer surprises me when someone walks in and tries it on. As for my job, I can't imagine doing anything else.

Another simple fix

I was contemplating the long grass in my backyard the other day and suddenly remembered a valuable lesson I had learned a while back. Eight months ago it was summer and my lawn can almost be seen growing at that time of year.

My lawnmower is one of those hardy Australian-made 2-strokes and has been incredibly reliable. As long as you follow the pre-start instructions listed on the handlebar-mounted control box, it always starts first pull. In fact, it had done so since the day I bought it over five years ago.

However, on one particular Saturday afternoon, it wouldn't – start, that is. Sweating buckets after what seemed like hundreds of pulls accompanied by various curses, throttle tweaks and carb-priming pumps, I decided it was "munted" and set about finding out why.

Now for those Australians have never encountered the word "munted", it was coined by officials for use in media briefings after the first Christchurch earthquake. This was because using that other commonly-used slang word for something that is horribly broken is frowned upon by our somewhat stodgy Broadcasting Standards Authority. Fortunately, this new word can be directly substituted for that other word, eg, my home/car/job/life is munted. Or those munting earthquakes have really munted my house.

So there it is – a powerful new word. Feel free to use it during the course of your own service work.

Now being a professional serviceman, I wouldn't attempt to repair something without knowing everything about it. No, disregard that last statement. I know next to nothing about lawnmowers but being a Kiwi male automatically qualifies me to have a go at fixing anything. Besides, I'm a trained aircraft engineer; it was only a lawnmower so how hard could it be?

I began by removing the pull-cord/cover assembly and petrol tank, crimping the fuel lines in the process to prevent leakage. I then undid the three bolts that secure the top crankcase cover and removed it. This immediately revealed that the large, square-profile rubber O-ring that surrounded and sealed the crankcase was crushed to nothing in one spot (ie, it was munted) and apparently had been since new. This breach could have finally let go, letting air in and crankcase pressure out and possibly explaining the mower's sudden reluctance to start.

Lawnmower repair is too easy, or so I thought.

After letting my fingers do the walking, I was lucky enough to find a mower-spares outfit that was open on a Saturday afternoon. Unfortunately, it was across town and it was a major mission to drive there after that first earthquake to get the part I needed.

When I got there, I noticed the far-away look in the mower-guy's eye when I told him I had found the fault and was fixing it myself. I suddenly found myself wondering if I look like that when customers come into my computer repair shop saying much the same thing. I sincerely hoped not because his look was rather condescending and I made a mental note to look further into it.

Back at the ranch, I replaced the gasket, gave the remaining parts a good clean and sealed it all back up. Then, with confidence borne of an accomplished serviceman, I set the throttle, primed the carburettor and pulled the cord. Nothing! A few more tweaks, pumps and pulls confirmed my professional diagnosis; it was still munted.

Cursing, I sat back with a cold beverage and pondered what could possibly be wrong. Was it the carburettor? Or the coil? Or something else.

Hitting the web, I found an excellent Australian-run mower-repair forum (how lucky was that?). And since I couldn't locate any information on this mower anywhere else, I "donated" money to the site in order to download several repair and service manuals. These proved to be incredibly helpful.

Unfortunately, after more disassembling, cleaning and checking that the vacuum governor, throttle and carburettor were all working as they should, it still didn't work. Munter!

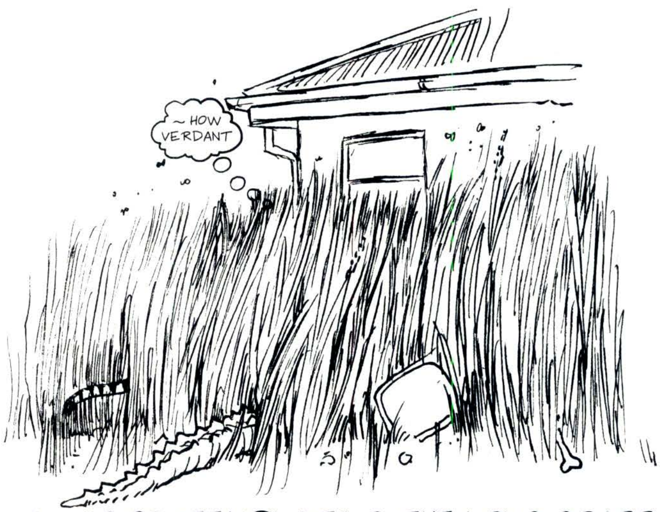
I was about to chuck it in when Dad arrived to collect something I had borrowed six months earlier and had been meaning to get back to him. "Did you check the plug?" he asked, with a look that said if you didn't, then you're an idiot. I had to admit it hadn't even occurred to me.

Grabbing a spanner, Dad removed the plug and propped it against the plug guard, telling me to try a few pulls. And just as he obviously expected (and as I now also expected), there was no spark. Either the plug was shot or the inductive ignition system was faulty.

OK, it was unlikely to be the ignition system but you have to cover all the bases. While I fumed at being so incredibly lame, we ducked around the corner to the local auto-spares shop and purchased two plugs, one for a spare.

After replacing the plug, the mower fired up on the first pull although it did run a bit rough for the first minute or two due to an over-rich mixture (a result of the previous starting attempts).

The lesson is that being technically competent doesn't necessarily mean we can automatically fix gear we are



I WAS CONTEMPLATING THE LONG GRASS IN MY BACKYARD THE OTHER DAY

not familiar with. Instead, it often causes us to over-analyse and miss the obvious.

Basically, we need to keep troubleshooting and repairs as simple as possible, starting with the most obvious solution and working backwards from there to the least-likely solution. Following this mantra would have saved me an entire afternoon of munting about.

Leaf blower repair

SILICON CHIP publisher Leo Simpson recently struck trouble with his venerable leaf blower. Here's his story . . .

In this era of throwaway appliances it's tempting to do just that – throw something away when it fails. But even though a replacement appliance or power tool may be relatively cheap, that isn't always the best course of action. And you may find that you cannot buy a suitable replacement anyway.

I was confronted by this dilemma recently when my Black & Decker leaf blower failed. It is about 10 years old and had never missed a beat until it failed, which is always the way!

In fact, on the last occasion I had used it, I noted that it had become reluctant to operate when I pressed the start switch. I had put it down to a problem with the start switch or perhaps the brushes were a bit worn.

The immediate challenge is how to pull these tools apart. Invariably, they are held together with tamper-proof screws and those screws are often deeply recessed. So even if you have a set of tamper-proof bits (eg, Altronics T-2180, Jaycar TD-2035 or TD-2038), you often cannot access them in the deep holes.

Splitting the casing of this Black & Decker leaf blower involved drilling out the access holes to the tamper-proof screws. The spring-loaded leaf-guard switch (arrowed) was the culprit.

And that was the situation with this leaf blower. I had the appropriate tamper-proof bit and could access some of the screws. However, there were some that were deeply recessed and the access holes were too small to allow the shaft of the bit driver to reach them.

Now the makers of these appliances may think they are being clever by using tamper-proof screws but when appliances are essentially throw-away anyhow because normal service charges make repairs uneconomic, why restrict access? Fortunately, I have access to a decent bench drill in the SILICON CHIP workshop so it was a 5-minute job to enlarge the holes in question with a 12mm drill.

That gave access and it was then a simple matter to remove all the screws and split the casing. In the event, there was no problem with the main start switch or the brushes. In fact, the motor appears to be very well made and there was little wear on the commutator or brushes.

Instead, the problem lay in the spring-loaded interlock switch which is actuated by the guard on the air intake. This guard can be removed when the unit is converted to a leaf "sucker", whereupon it sucks the leaves into a canvas bag.

Anyhow the switch had become a little "tired" and it was not closing properly. Now while I intend to obtain a replacement switch from the Black & Decker agents, my immediate solution was to bypass the switch. This does present a safety problem until the switch is replaced but in any case, now that I come to think about it, the switch had been inoperative for some time and was effectively closed even if I inadvertently left the guard off.

The moral of this story is that you don't necessarily have to discard an appliance if it stops working. A simple investigation and a quick repair can mean that the unit still has many years of life in it. My drilling out of the screw access holes risked damaging the casing beyond repair but I had nothing to lose and everything to gain. **SC**

FOR THE DAD WHO LOVES HIS CAR!

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QM-3781 WAS $99.00

$89.00 SAVE $10.00

Steelmate Entry Level Car Alarm with Voice Function

Make Dad's car secure! An affordable car alarm that features voice feedback on alarm status and operational parameters such open doors etc. Other features include boot release button, valet mode, and emergency override.

$99.00

- The pack includes electronic black box controller, shock sensor, ignition cutout relay, speaker siren, wiring looms, bonnet pin switch, car charger for the remote controls, extra circuits for fuel and ignition cutout, 2 x code hopping remote control units with a built in torch

LA-9003

FREE Spare Remote (LA-9004) valued at $37.95 with every purchase!

DAD'S WISH LIST

USB Car Charger for iPad®/iPhone®/iPod®

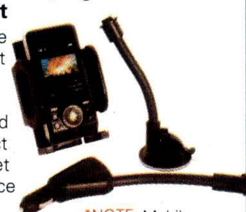
Charge your Apple® devices while you're driving. Simply plug into the car's cigarette lighter outlet. The USB port outputs a huge 2.1A to fast charge an iPad®.

- Includes a USB charging cable to suit iPad®/iPhone®/iPod®

MB-3657

$24.95

Gooseneck Windscreen/Cigarette Lighter GPS Mount



Plug into a car cigarette lighter socket or mount it on the windscreen glass. The gooseneck allows it to be mounted where it won't obstruct your vision. The bracket adjusts to fit your device and can be rotated through 180° to accommodate wider devices, such as larger GPS units. The cigarette lighter mount has a piggyback socket so you can use the outlet to power your device.

*NOTE: Mobile phone not included

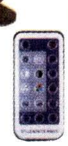
- Base diameter: 67mm
- Gooseneck: 180mm long

HS-9002

$34.95

7" TFT LCD WIDESCREEN COLOUR MONITOR WITH IR REMOTE

A truly versatile monitor with low power consumption, wide viewing angle and NTSC and PAL compatibility. Suitable for in-car and home entertainment, use it to watch DVDs, PS2®, XBOX®, etc. Two RCA composite video inputs and one audio input are provided for a multi source system. Unit comes with an adjustable swivel bracket with double sided tape for adhesion on clean flat surfaces. Also includes infrared remote control.



- Power input: 12VDC
- Resolution: 1140(H) x 234(V)
- Inbuilt speaker
- Reverse image capability

QM-3752 WAS $159.00

$129.00 SAVE $30.00

ALCOHOL BREATH TESTER

It measures up to a blood alcohol level of 0.2%. Response time is less than 8 seconds - all you do is wait about 10 seconds then blow into the sensor to give a reading in blood alcohol percentage or mg/litre. Requires 2 x AAA batteries.

- Compact purse or glove box size
- Backlit LCD
- Dimensions: 103(L) x 37(W) x 19(H)mm

Great gift for Dad!

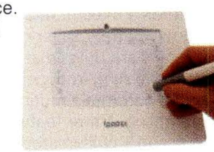
Please note: This product is intended to give an indicative reading only and is carries no guarantee of accuracy. Jaycar accepts no responsibility for any consequence arising from the use of this device.

QM-7298 WAS $29.95

$19.95 SAVE $10.00

5.5" GRAPHICS TABLET

Using a graphics tablet is completely natural, more comfortable, pressure sensitive, higher resolution and far more accurate than a mouse. The pen has user defined buttons and "hotspots" around the border of the tablet. Paint, draw, write, touch up or use it as a pointing device. Absolutely essential tool for graphics designers, photographers or other creatives.



- Battery and software included
- Windows 2000, XP, Vista or Mac
- Dimensions: 205(W) x 190(H)mm

XC-0356 WAS $59.95

NOTE: Requires storage media up to 32GB SD card

$49.95 SAVE $10.00

SHIATSU NECK MASSAGER WITH VIBRATION & HEAT

NEW 2011

Dad can sooth tired neck muscles with a deep and relaxing massage in home or office. Relieve stress and tension with 3 massage modes - Shiatsu, vibration or Shiatsu & vibration. Also features an additional heat mode perfect for unwinding after a long hard day.

- Easy to use
- Mains powered
- Size: 340(L) x 300(W)mm

GH-1764

Give Dad a massage

$79.95

FATHER'S DAY CHARGER SPECIALS

In-Car Battery Charger

Recharges 2 x AA or 2 x AAA Ni-Cd or Ni-MH batteries using Delta V voltage detection which ensures the batteries are charged to their optimal levels for long life. Charge state can be monitored on the integrated LED. Keep a spare set of batteries topped up and ready to go, wherever you are.

- Includes bad cell detection
- 900mA charging current for AA batteries
- 450mA charging current for AAA batteries
- Dimensions: 130(L) x 45(W) x 30(H)mm

MB-3552 WAS $18.95

$9.95 SAVE $9.00

Universal Li-Ion/Li-polymer Battery Charger with Status Display

Designed with an adjustable battery tray to accept almost any standard 1 or 2 cell rechargeable Li-Ion/Li-polymer battery. The unit has automatic battery voltage and polarity sensing as well as bad battery detection. The charger is supplied with both mains and car adaptors.

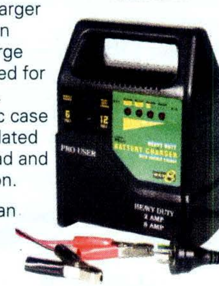
- Adjustable charging current 400/800mA
- Dimensions: 143(L) x 64(W) x 30(H)mm

MB-3587 WAS $44.95

$34.95 SAVE $10.00

Heavy Duty 6A Battery Charger with Trickle Charge

Suitable for both 6 and 12 volt car, boat, motorcycle and lawnmower batteries. Featuring 4-stage LED charge indicators, the charger can be switched between trickle or heavy duty charge rates and is recommended for domestic charging tasks. Housed in a tough plastic case with handle, double insulated and also features overload and reverse polarity protection.



- Complies with Australian Electrical Safety Regulations

MB-3522 WAS $59.95

$49.95 SAVE $10.00

FOR THE MUSIC LOVING DAD!

USB Turntable with Amp

Copy Dad's LPs, 45s or even 78s straight to his PC, or simply listen to his record collection via the built-in amp and speakers. The unit has an auxiliary RCA outputs so Dad can run it to a separate amplifier. Finished in contemporary white piano finish with blue LED accents.

- USB cable and software included
- Suits XP, Vista & MAC
- Measures: 320(W) x 265(D) x 85(H)mm

GE-4056

$69.00

Turntable with Built-in Pre-Amplifier & PC Encoding

Convert Dad's old vinyls to modern digital WAV, MP3 or OGG format. This contemporary design turntable has a high quality magnetic cartridge which ensures clear and distortion free conversion. Equipped with a built in pre-amp and line level RCA output. Features a selectable belt drive system and an auto stop function.

- Mains powered
- Dimensions: 370(L) x 350(W) x 95(H)mm

GE-4134

$99.00

Unidirectional Balanced Professional Vocal Dynamic Microphone

A top quality balanced mic suitable for singing and band work. Supplied with 3 pin Cannon lead and 6 metre cable. Case made of zinc-diecast. Compares with the Shure SM58!

- Type: Unidirectional balanced dynamic
- Impedance: 500 ohm
- Termination: 6 metre Cannon to Cannon 3 pin

AM-4096 WAS $69.95

$49.95 SAVE $20.00

Also available: **Low Cost Unidirectional Dynamic Microphone** AM-4090 WAS $14.50 NOW $9.95 SAVE $4.55

2.4GHz 4 CHANNEL RC HELICOPTER

Super light and extremely rigid aluminium frame helicopter with four channels allowing you to control the elevation, forward, back, bank left/right and left/right rotation. It has a built-in gyroscope for stable flight and 2.4GHz remote control commonly found on much more expensive RC systems. Rechargeable lithium polymer battery and mains charger included. 20 minutes charge gives about 10 minutes flight time.

- Chopper battery: 7.4V Li-Po 850mAh
- Remote unit requires 8 x AA batteries
- Recommended for ages 10+
- Size: 360(L)mm

GT-3340 WAS $179.00

$149.00 SAVE $30.00

Great gift for Dad!

Spare parts available separately

Li-Po battery	GT-3341 $29.95	SAVE $10
Rotor blade set	GT-3342 $9.95	SAVE $5
Gear Set	GT-3343 $7.95	SAVE $5
Balance bar/buckle	GT-3344 $7.95	SAVE $5

SLIMLINE TV BRACKETS

Projecting only 10mm from the wall, these slim-line brackets are very easy to install and will accommodate an LED, LCD or plasma TV up to 80kg and 60" size. Designed with a simple cleat attachment system, two bars screw to the back of the TV on standard VESA spacings. The spring-loaded cleats lock in position so the TV can't be accidentally knocked off. Not just a budget solution, they are simple, effective and take up very little space ideal for small apartments. Two models available (23-37" or 32-60" size).

- Fits standard spacing wall studs
- Ultra-low profile
- Easy installation, easy removal
- Mounting hardware included

Great gift for Dad!

23 - 37", 45kg
CW-2821 WAS $39.95
NOW $29.95 SAVE $10.00

32 - 60", 80kg
CW-2823 WAS $49.95
NOW $39.95 SAVE $10.00

FROM $29.95 SAVE $10

USB POWERED PC SPEAKERS

Portable USB powered speakers for use with laptops, desktop PCs or mobile music players. Contemporary, space saving design with plug and play functionality. Also features separate volume control, power switch and headphone output.

- Impedance: 6 ohms
- Power output: 1.8WRMS
- Dimensions: 154(H) x 75(W) x 36(D)mm

XC-5191

$14.95

COMPUTER SERVICE TOOL KIT

Ideal for computer service technicians or the talented amateur. Included in this service kit is an IC inserter/extractor, pearl catch, tweezers, 1/4" nutdriver, 3/16" nutdriver, parts tube for storage, double ended 10/15 torx driver, #0 and #1 Phillips screwdriver, 1/8" and 3/16" Slotted screwdriver and black zipper case.

- Case measures: 220(H) x 155(W) x 38(D)mm

TD-2040 WAS $29.95

$24.95 SAVE $5.00

DUAL CHANNEL UHF AUTOSCAN DIVERSITY WIRELESS MICROPHONE

Features 16 user-selectable channels on each microphone input to provide interference-free transmission. It also has phase locked loop (PLL) circuitry for frequency stability. Each channel has an LCD which displays the channel selection, frequency and signal strength. Output is either via separate balanced line for each channel, or via an unbalanced 6.5mm mono line with the two channels signals mixed. Suitable for professional and stage use!

- Includes 2 microphones with batteries and receiver unit in 19" rack-mount chassis
- Transmitter range: 100m
- Power: 12 - 18VDC (power supply included)
- Dimensions: 420(L) x 210(W) x 45(D)mm

AM-4120 WAS $399.00

$349.00 SAVE $50.00

Additional microphones sold separately:

Wireless handheld mic: Ch A AM-4121 $149.00
Ch B AM-4128 $149.00

PORTABLE A4 COLOUR SCANNER

Capture A4-size documents, book, letters, photos etc. directly to a MicroSD card or save image files to computer via USB cable. No PC or software required. The LCD displays scanning status, resolution, battery life and memory status.

- Auto power off after 3 minutes
- Requires MicroSD card up to 32GB
- Up to 600 x 600 resolution
- USB interface
- Requires 2 x AA alkaline batteries
- Dimensions: 256(L) x 30(W) x 31(H)mm

XC-4909 WAS $149.00

$129.00 SAVE $20.00

Handles up to A4 size paper!

FOR THE SPORTY DAD!

Sports Stopwatch

This handy sports timer is a useful addition to Dad's sports bag. It measure elapsed time for up to 24hrs, has a split time (Lap) function as well as alarm and calendar functions. Water resistant stopwatch!

- Includes 600mm lanyard
- Dimensions: 55(W) x 65(H) x 15(D)mm

XC-0270

$12.95

Great gift for the active Dad!

High Performance Stopwatch

Perfect for timing laps! This unit will do 999 laps and splits, fastest, slowest & average lap display and can count rowing strokes rates. Up to 100 lap times stored in memory and is water resistant. Black in colour, and includes lithium battery and lanyard.

NEW

- Pacer function
- Dual timer
- Dimensions: 68(L) x 82(W) x 21(H)mm

XC-0287

$24.95

BUDGET 300K WEB CAM

No built-in camera on the laptop? Add one at minimal cost. Microphone included, plug and play. Low cost solution.

- Supported in Windows XP, Vista, 7
- No drivers required
- Size: 32(W) x 42(H) x 28(D)mm

QC-3235

$14.95

Automotive & Outdoors

CENTRAL LOCKING DEALS!

2 Door Power Lock Kit

Add the convenience of central locking to your car with this low cost 2 door central locking kit. Durable and easy to install.

- Supplied with 1 master and 1 slave actuator, control relay, hardware and wiring loom.

LR-8810 $29.95

DEAL 1
Buy 1 x LR-8839 & 1 x LR-8810 for $75 Save $24.90

4 Door Power Lock Kit

Low cost 4 door central locking kit. When you unlock the drivers door the other three doors will also unlock. It can be connected to car alarms with a negative triggering locking output, or used with our LR-8839 remote controller for keyless entry.

- Supplied with 1 master and 3 slave actuators, control relay, hardware and wiring loom.

LR-8812 $39.95

DEAL 2
Buy 1 x LR-8839 & 1 x LR-8812 for $85 Save $24.90

Remote Keyless Entry for Central Locking Systems

Upgrade to a remote keyless car entry with this system. On rainy or windy days where you need a quick entry, unlock your doors as you approach the car. The system is easy to install and comes with two remote key fobs.

LR-8839 $69.95

BUDGET RESPONSE CAR SPEAKERS

Ideal replacement for the standard equipment stereo speakers Dad can get in the average car. All are equipped with titanium coated fibre woofers and silk dome tweeters for smooth high frequency response.

- Nominal impedance: 4 ohms

RESPONSE

CS-2312

FROM $24.95

4" Coax 2 Way Car Speakers

- Power handling: 15WRMS

CS-2310 WAS $24.95
NOW $19.95 SAVE $5.00

5" Coax 2 Way Car Speakers

- Power handling: 17WRMS

CS-2312 WAS $29.95
NOW $24.95 SAVE $5.00

6" Coax 2 Way Car Speakers

- Power handling: 22WRMS

CS-2314 WAS $34.95
NOW $29.95 SAVE $5.00

6 x 9" Coax 2 Way Car Speakers

- Power handling: 27WRMS

CS-2316 WAS $44.95
NOW $39.95 SAVE $5.00

3-STAGE 6/12V AUTOMATIC BATTERY CHARGER

Automatically diagnoses, recovers and recharges 6 or 12 volt lead-acid, gel, and AGM rechargeable batteries for boats, motorcycles etc. Maintains your battery for months and extends battery life by constantly monitoring battery condition and bulk, trickle or maintenance charges accordingly. Handy storage hooks for alligator clips keep the lead out of the way when not in use.

$49.95

Great gift for Dad!

- Output voltage: 7.2, 14.4VDC
- Dimensions: 110(L) x 62(W) x 45(H)mm

MB-3603

UNDER CAR LED LIGHT KIT WITH REMOTE CONTROL

Switchable by remote control between red, green and blue. The kit comprises four 630mm long PVC strips with 12 groups of three LEDs and 2.5m cable, making it easy to position the strips for optimum effect. All you need to do is connect 12V. Ideal for street or show.

SL-3955 WAS $89.95

$69.95 SAVE $20.00

MP3/USB FM MODULATOR FOR IPHONE® AND IPOD®

Plug into the cigarette lighter socket, tune to the FM band on your car radio to play and charge your iPod®, iPhone® or any other MP3 player using the 3.5mm stereo cable included. It also has a USB socket, so you can play tunes from a flash drive.

*NOTE: iPhone® not included

- Range: 5m
- Dimensions: 110(H) x 65(W) x 40(D)mm

AR-3113 $49.95

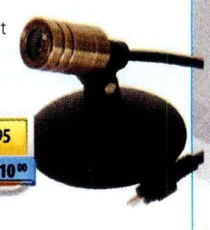
Also available:
In-Car Bluetooth FM Modulator
AR-3111 $99.00

IP67 LED LANDSCAPE SPOTLIGHTS

Add some luminescence to your outdoor or aquatic landscape! These lights are IP67 rated for complete protection against the weather, extremely robust so will last for many years. Can be mounted in a water feature or rock pool. Being LED, they use very little power and will last for thousands of hours. Each can be mounted on a surface or on the stout spike and thrust into the ground in a convenient location. Each has a 5m length of cable and extension cables and splitters available. 1W or 3W types.

- Provides natural-looking light
- Energy efficient

1W IP67 LED Garden Spotlight



- Equivalent to a 10W halogen light
- Size: 70(L) x 30(Dia)mm

SL-2755 WAS $29.95

$19.95 SAVE $10.00

3 x 1W IP67 LED Garden Spotlight

- Equivalent to a 20 Watt halogen light
- Size: 86(L) x 62(Dia)mm

SL-2756 WAS $59.95

$49.95 SAVE $10.00

Accessories available separately

Power Supply 12VAC 12W SL-2757
WAS $24.95 NOW $14.95 SAVE $10.00

Power Supply 12VAC 24W SL-2754
WAS $39.95 NOW $24.95 SAVE $15.00

Extension Cable 5m Screw Lock SL-2759
WAS $19.95 NOW: $9.95 SAVE $10.00

Cable Splitter SL-2753
WAS $12.95 NOW $9.95 SAVE $3.00

NEW RANGE OF TV ANTENNAS/MASTS

Caravan/RV (general purpose) Mast

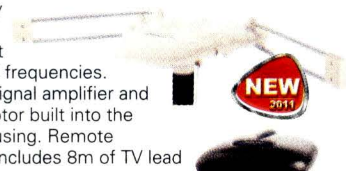
Aluminium telescopic mast suitable for TV and other antennas. Extends to 1.5m in 3 sections. Compatible with almost all TV antenna mounting hardware. It has a sturdy cap and features a slot, which enables you to neatly thread the coax lead down through the mast.

NEW 2011

- Natural finish
- Maximum height 1.5 metres

LT-3204 $24.95

Outdoor UHF/VHF/Marine TV Antenna



Digital ready outdoor antenna that works on all frequencies. Includes a signal amplifier and a rotator motor built into the antenna housing. Remote controlled. Includes 8m of TV lead with weatherproof plug.

NEW 2011

- Includes booster amp which will drive 2 x TVs
- Compatible with LT-3204 telescopic mast.
- Output 80 dbuV.
- Antenna measures: 750(W) (deployed) x 30(L) x 100(D) (mm) (Folds down for storage)

LT-3143 $59.95

Telescopic Antenna Mast

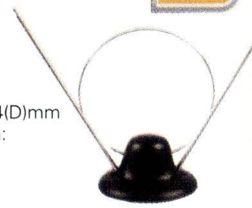
With adjustable height and durable aluminium construction, this versatile telescopic antenna mast is suitable for just about any domestic application as well as marine and mobile use.

- Easy installation and height adjustment
- 36mm diameter
- Includes 3 guy wires for assured stability
- Maximum height 4.5 metres

NEW 2011

LT-3202 $59.95

Indoor UHF/VHF Passive TV Antenna



NEW 2011

Ideal for areas with good indoor TV signal. This passive indoor antenna picks up TV signals without needing connection to power. Features both a UHF loop and extendable VHF rabbit ears.

- Base and UHF Loop: 190(H) x 120(W) x 84(D)mm
- VHF Antenna Length: 220-800mm
- Cable Length: 1.6m

LT-3114 $9.95

TEST EQUIPMENT KITS - BUILD THEM!

Transistor Tester Kit

Refer: Electronics Australia September 1983

Have you ever unsoldered a suspect transistor only to find that it checks OK? Troubleshooting exercises are often hindered by this type of false alarm. You can avoid these hassles with the In-Circuit Transistor, SCR and Diode Tester. The kit does just that, test drives WITHOUT the need to unsolder them from the circuit! VERY HANDY!

- Voltage drop & temperature rise (dT/dt) full charge detection for Ni-Cd & Ni-MH
- Under and over temperature cut-out for battery protection
- Over temperature cut-out for charger short circuit battery protection
- Time-out protection fuse protection
- Multi-LED charge indicators
- Kit includes case, professionally punched & silk-screened panels, PCB, quality toroidal plus all specified electronic components
- PCB: 70 x 57mm

KA-1119

$27.95

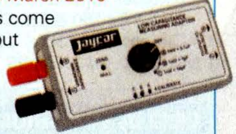
Low Capacitance Adaptor for DMM Kit

Ref: Silicon Chip Magazine March 2010

Many modern multimeters come with capacitance ranges, but they're no good for very small values. This kit is a nifty little adaptor that allows a standard digital multimeter to measure very low values of capacitance from less than one picofarad to over 10nF. It will allow you to measure tiny capacitors or stray capacitances in switches, connectors and wiring. The kit is complete with PCB, components and case. All you'll need is a 9V battery and just about any modern DMM.

- PCB: 51 x 90mm

KC-5493



$34.95

PROFESSIONAL BENCH ENCLOSURE

Features pre-punched ventilation holes, metal thread fastening screws, and aluminium pre-painted front and rear panels. This enclosure comply with standard IEC297 rack heights.

- Colour: Grey
- Size: 88(H) x 279(D) x 304(W)mm

HB-5556 WAS $59.95

$49.95 SAVE $10.00

INDUSTRIAL IP66 STAINLESS STEEL ENCLOSURE

Perfect for any project requiring the protection provided by stainless steel. A foam rubber seal inside the lid protects against dust and moisture giving the enclosure an IP66 rating.

- Heavy duty enclosure
- Wall thickness: 1.5mm
- Dimensions (Overall): 150(W) x 150(H) x 85(D)mm

HB-6413

NEW 2011

$89.95

MICRO BLOW TORCH - LARGE FLAME

A compact, versatile large flame micro blow torch Dad should keep close by for all his DIY or culinary projects. Adjust the flame size to suit a wide variety of applications including brazing, heat shrinking and cooking.

- Flame Temperature: 1300°C
- Auto ignition (Piezo)
- Child Restraint/Safety Latch
- Butane gas refill: **NA-1020** $5.95 (sold separately)
- Dimensions: 128(L) x 65(W) x 156(H)mm

TS-1661

NEW 2011

$49.95

NON-CONTACT THERMOMETERS

Non-Contact Thermometer with Dual Laser Targeting

Measure the temperature of any surface from a safe distance with this compact sized non-contact thermometer.

- Backlit LCD
- 12:1 distance to target ratio
- Temperature: -50 to 650°C
- Accuracy: ±1%
- Holster included
- Dual laser pointer
- Dimensions: 146(L) x 104(W) x 43(D)mm

QM-7221

$99.00

For the DIY Tradesman Dad

Pro High Temperature Non-Contact Thermometer

This professional infrared thermometer measure high temperatures with safety. Suitable for lab, furnace, forge and small-scale foundry work. The laser pointer allows accurate placement of the measurement point and the 30:1 distance-to-target ratio allows accurate measurement from greater distances.

- 30:1 distance to target ratio
- Temperature: -50 to 1000°C
- Accuracy: ±1.5%
- Built-in laser pointer
- Automatic data hold
- Max and min logging
- Moulded carry case included
- Dimensions: 230(L) x 100(H) x 56(W)mm

QM-7226 WAS $189.00

$169.00 SAVE $20.00

ROTARY TOOL KIT WITH FLEXIBLE SHAFT

The kit consists of a powerful 32,000 RPM rotary tool that you can use with numerous (210 piece) attachments in the usual way, plus a 1m long flexible shaft that attaches in seconds to give extra versatility. Suitable for model making, automotive, workshop, art, jewellery or sculpture. See website for full kit contents.

- Power: 135W
- Size: 210(L) x 52(Dia)mm

TD-2459

$39.95

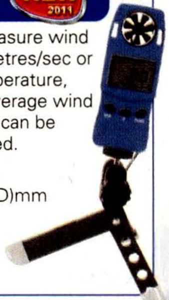
HAND-HELD ANEMOMETER WITH TRIPOD STAND

NEW 2011

A hand held anemometer that measure wind speed in feet/min, MPH, km/h, metres/sec or knots. Measure windchill, air temperature, displays current, maximum and average wind speed. Beaufort scale display and can be hand held or fixed to stand supplied.

- Wind speed: 0.64 to 107.8 km/h
- Measures: 115(H) x 45(W) x 16(D)mm less stand

QM-1644



$69.95

WIRE DRAW FISH TAPE

The smart way to draw cable through wall cavities or conduit. 30m of rigid spring steel with a built-in cable clip on one end that rolls up into its own case after use. No electrician or installer Dad should be without one!

- Length: 30m
- Size: 305(Dia) x 38(H)mm

TH-1869

$29.95

DIGITAL THERMOMETERS

Digital Thermometer with K-Type Thermocouple

A handy pocket-size digital thermometer, suitable for the lab, workshop or in the field. It features an excellent measurement range from -50 to 750°C and a hold function to lock the reading on the display.

- Temperature: -50 to 750°C
- Accuracy: ±1%
- Dimensions: 118(L) x 70(W) x 29(D)mm

QM-1602 WAS $39.95

$34.95 SAVE $5.00

Thermocouple & battery included

Pocket Sized Non-Contact Digital Thermometer

Featuring an easy to read LCD, this handy little unit can go with you anywhere. Monitor performance of appliances such as refrigerators, dishwashers, freezers or ovens. Handy for use in the kitchen or the food service industry to ensure proper cooking, grilling and storage temperatures.

- Temperature: -35 to 230°C
- Accuracy: ±2%
- Dimensions: 74(L) x 40(W) x 20(D)mm

QM-7225 WAS $34.95

$29.95 SAVE $5.00

Battery included!

Mini Non-Contact IR IP67 Thermometer

Ultra compact, non-contact thermometer. IP67 rated so is ideal for industrial and lab applications. LCD readout gives temperature in Celsius or Fahrenheit.

- Size: 82(L) x 17(Dia)mm
- Temperature: -33 to 110°C
- Accuracy: ±2.5°C

QM-7218 WAS $39.95

$29.95 SAVE $10.00

Batteries & lanyard included!

SMART POWERBOARD WITH ENERGY METER

NEW 2011

6 way powerboard perfect for saving on standby power consumption! One socket never switches off and one 'smart' outlet can be used for your main item such as your computer. When you switch off your computer it will then switch off your related items (e.g printer, scanner etc.). Also features an energy meter that tells you the energy consumption of the devices plugged into the smart powerboard in watts, cents per hour or CO_2 kg per hour. Easy to use, simple set up!

- Surge protection, overload, spike and noise filtering
- 900mm long power cord
- Measures: 385(L) x 60(W) x 30(D)mm

MS-6152

$59.95

LED WORKLIGHTS

Poly-lumen Table Lamp & Torch

NEW 2011

A versatile light source great for reading in the bedroom, shed or on Dad's BBQ. It also doubles as a detachable hand torch. Adjust light accordingly with the flexible goose neck & clamp onto table tops up to 2.5cm thick.

- 3 x ultra bright white LED
- Requires 3 x AA batteries
- Torch dimensions: 165(L) x 40(W)mm
- Stand dimensions: 190(H) x 120(W)mm

ST-3462

$24.95

Great gift for Dad!

Rechargeable Magnetic Work Light

Perfect for boating, camping, working on the car or for emergencies. With 61 super bright LEDs, it provides enough light for any situation. Equipped with two powerful magnetic clip-on brackets for fixing metal surfaces, leaving your hands free. It can be recharged with a mains charger or via a car cigarette lighter outlet.

- Water, oil and shock resistant
- Recharging time: 3 hrs
- Mains and car chargers included

ST-3021

$49.95

80 LUMEN 4 MODE LED LANTERN

Innovative outdoor lantern with ultra bright LEDs. Great for Dad's next outdoor adventure or camping trip. Weatherproof design and features 3 different light functions & a flashing mode. Stands on flat surface or use the attached metal hook to hang the lantern anywhere.

NEW 2011

- 6 x ultra bright white LEDs
- Burn time: 20 hours (steady) 40 hours (flashing)
- Requires 3 x AA batteries
- Dimensions: 150(H) x 85(Dia)mm

ST-3123

$24.95

3W LED TORCH WITH SOLAR RECHARGING COMPARTMENT

A powerful 3W Nichia LED torch that can be charged from the solar compartment. The torch slides into the compartment and is then sealed with a screw on lid. Leave the compartment on the dashboard of your car to recharge its battery then slide the torch out when ready to use. For Dad's next camping and long trips away from mains power.

NEW 2011

- Power: 3W
- Battery: 1 x 3.2V 1200mAh Li-Ion rechargeable battery (included)
- Lumens: 150
- Burn time: 2.5 hours (8hr charge)
- Water resistant
- Dimensions Torch: 166(L) x 34(Dia)mm Solar compartment: 198(L) x 55(H) x 95(D)mm

ST-3469

$69.95

MOTION ACTIVATED SENSOR LIGHT WITH LED

NEW 2011

Multi purpose LED light with built-in infrared sensor designed to turn on automatically for 25 seconds when the PIR sensor detects movement (up to 4 metres away). Detach the light to double as a portable LED torch. Adjustable bracket and screws supplied.

- 3 modes
- 3 x ultra-bright white LED
- Requires 3 x AA batteries
- Dimensions: 193(L) x 40(W)mm

ST-3461

$24.95

BATTERY CHARGERS

AA & AAA Battery Charger with LCD

Recharge up to four AA or AAA Ni-Cd or Ni-MH batteries. With Delta V voltage detection, the batteries are charged to their optimal level. Charge state can be monitored on the integrated LCD.

- Easy to read and backlit LCD
- Supplied with mains and car chargers
- Dimensions: 120(L) x 70(W) x 28(H)

MB-3543 WAS $49.95

$39.95 SAVE $10.00

Super Fast 15 Minute Charger for AA & AAA Ni-MH Batteries

The charger uses Delta V voltage detection to charge the batteries to optimal levels and ensure long battery life. Car charging cable and mains plugpack included.

- Charge at the home, office or on the road
- Includes bad cell detection
- 4 Individual charging channels
- Use our Enekeep pre-charged batteries for peak performance (See SB-1750 & SB-1752)
- Dimensions: 130(L) x 78(W) x 36(H)mm

MB-3531 WAS $69.95

$59.95 SAVE $10.00

4 x AA pre-charged batteries included

CR123A 3V LITHIUM BATTERIES

NEW 2011

Contains 6 x CR123A lithium camera batteries, commonly used in LED torches and cameras.

- Pack of 6

SB-2324

Buy in bulk & save!

$17.95

FIBRE OPTIC ADAPTOR FOR MAGLITE®

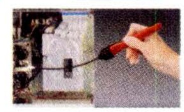
Light only travels in straight lines, but Dad can make it bend with this Fibre Optic adaptor. A small attachment fits right over the head of the torch, and is attached to a 180mm (7") fibre optic cable. With a diameter of just 3mm, it really can get into those tight spaces.

$9.95 SAVE $5.00

- Flexible light source
- Works also with similar sized flashlights

ST-3410 WAS $14.95

NOTE: Torch not included



SMD LED STRIPS

8mm LED Solid Strip Lighting

For builders, architects, shop fitters, home handymen and DIY enthusiasts alike; our new range of LED solid strip lighting is efficient, low cost, and LED lighting solutions on wide range of applications. Mounted on a 3M brand self adhesive backing tape, and fitted with wide angle, high brightness SMD LEDs. Powered by either 12VDC or 24VDC.

- 8mm strips fitted with 3528 single chip SMD LEDs
- Strips can be snapped into individual segments and powered individually
- Strips can be integrated with our aluminium and plastic extrusions and diffusers

12V 200mA	30 x White	**ZD-0461**
12V 200mA	30 x Warm White	**ZD-0463**
24V 100mA	30 x White	**ZD-0465**
24V 100mA	30 x Warm White	**ZD-0467**

NEW 2011

$19.95 each

ZD-0461

IP66 Aluminium Backed LED Strips

IP66 rated with a solid aluminium backing for installation in tougher environments, these are the LED strip lights of choice for marine, caravan, motorhome, or outdoor domestic and architectural applications. Powered by 12VDC and available in warm white and cool white colour temperatures.

- Fitted with flyleads and weatherproof connectors for easy installation

12V 200mA 8mm	30 x White	**ZD-0468**
12V 200mA 8mm	30 x Warm White	**ZD-0469**

NEW 2011

$29.95 each

ZD-0468

DIN RAIL MOUNTING AC CIRCUIT BREAKERS

NEW 2011

DIN rail mounted circuit breakers for domestic and commercial switchboards, fuse boxes, distribution boards etc. Standard DIN profile.

- Electrical safety authority approved.
- 240VAC

Single Pole 10A	SF-4150
Single Pole 16A	SF-4151
Single Pole 20A	SF-4152
Single Pole 32A	SF-4153

$6.95 each

SOLAR POWERED BUTTERFLY

Colourful full-sized butterfly hovering in your window box or garden when the sun comes out. When it doesn't a 1.5V x AA battery (not included) takes over. Includes solar cell, mounting spike and butterfly.

- Measures: 450mm high

GH-1834

NEW 2011

$19.95

RC FLYING MACHINES

2-Ch RC Twin Engine Model Jet

With 2 channels this jet is driven by two brushless motors, one in each wing and is steered by varying the power to either engine so this makes it easy to control. Made from ultra-light Styrofoam it can handle all the knocks and crashes without causing serious damage. Supplied in ready to-run kit form with lithium-ion battery and is controlled by a responsive remote control.

- Recharges in 20 - 30 minutes for approx 5 - 6 minutes of flight time
- Suitable for ages 8+
- Wingspan 290mm
- Remote requires 6 x AA batteries

GT-3780 WAS $49.95

$39.95 SAVE $10.00

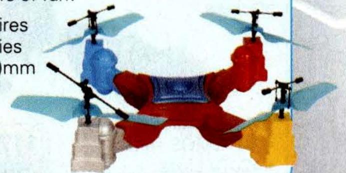
4-Ch RC 4 Engine UFO

A four-engine, four-rotor flying widget. Each channel and motor on the craft is colour-coded so you can easily identify what makes it go where. It has a built-in rechargeable Li-ion battery that recharges from the remote unit. 20 minute charge gives about 5 minutes of flight time. Once you get the hang of it, you'll have hours of fun!

- Remote requires 6 x AA batteries
- Size: 230(Dia)mm

GT-3782
WAS $69.95

$59.95 SAVE $10.00



4CH IR GYRO HELICOPTER

Fly to Pandora with this 4 channel remote control helicopter inspired by the movie. Dip, turn, spin or hover just like you see in the movies. Outstanding performance with stable flight and magnificent hovering capabilities with its built-in gyroscope. Recharges via the quick connect lead from the remote control. Excellent for beginners and first time flyers.

NEW 2011

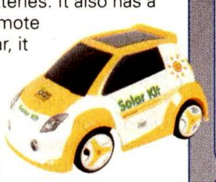
- Infrared remote control
- Durable and shockproof metal frame chassis
- Remote requires 6 x AA batteries (not included)
- Dimensions: 230(L) x 130(W) x 105(H)mm
- Suitable for ages 14+

GT-3386

$49.95

RECHARGEABLE MINI SOLAR RC CAR

The fun way to teach your children the benefits of renewable energy sources! This neat little remote control car has a solar panel on the roof charging the on-board rechargeable batteries. It also has a charge dock station for the remote control. A full functional RC car, it has forward, reverse, left and right controls. Also comes with a USB charger for those cloudy and rainy days.



NEW 2011

- Solar powered
- Lightweight
- Suitable for ages 8+
- Dimensions: 240(L)mm

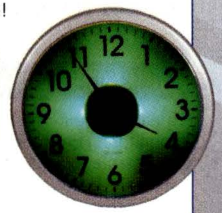
GT-3699

$29.95

LED BACKLIT WALL CLOCK

A wall clock with a difference! Set the backlight to come on automatically when the lights go out, or turn it on or off manually.

$14.95 SAVE $10.00



- Requires 4 x AA batteries
- Size: 305(Dia)mm

AR-1763 WAS $24.95

LED REMOTE CONTROLLED OPEN/CLOSED SIGN

High visibility shop sign with LED open/closed display can be seen from a considerable distance so customers know if your shop is open for trading or not. It has a clock display that shows hours, minutes and seconds and you can disable the open/closed display if required. The display is remote controlled and runs from a 9V mains adaptor.

$129.00 SAVE $40.00

- Dimensions: 362(W) x 242(H) x 25(D)mm

XC-0200 WAS $169.00

COLOUR CODED KEY FINDER

Simply press the colour coded button allocated to your keys on the main unit and the matching receiver will beep so you can find those missing keys. The base unit can be placed on a counter top or be wall mounted. Stand included.

- Transmits radio signal up to 25m away
- Colour coded key fobs beep when activated
- Key fobs incorporate LED flashlight
- LEDs illuminate while transmitting
- Required 3 x AA Batteries

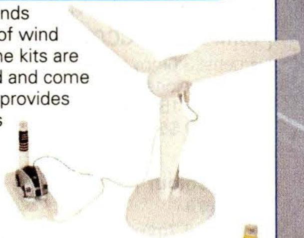
XC-0353 WAS $49.95

$34.95 SAVE $15.00

Help Dad find his keys!

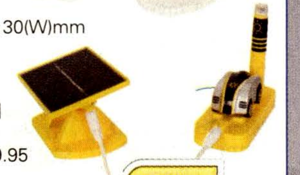
WIND AND SOLAR POWERED RC CARS

Educate curious minds about the concept of wind and solar power. The kits are very simple to build and come with a manual that provides construction details and explains how alternative energy can generate electricity.



- Car size: 60(L) x 30(W)mm

Two models to choose from:



Wind Powered RC Car
KJ-8838 WAS $49.95

Solar Powered RC Car
KJ-8839 WAS $49.95

$34.95 each SAVE $15.00

WIRELESS NETWORK ADAPTORS

150Mbps Nano 802.11n USB 2.0 Wireless Network Adaptor

A miniscule USB wireless network adaptor that is ideal for a laptop. Despite its size, it still features MIMO technology for increased throughput and range, backward compatibility with 802.11b/g networks and the full spectrum of encryption and security features.

NEW 2011

- 64-bit / 128-bit WEP (Wired Equivalent Privacy), TKIP, AES 2.400GHz ISM
- Compatible with Windows 2000, XP, Vista, Linux and MAC OS X
- Dimensions: 61(L) x 21(W) x 7(H)mm

YN-8308

$19.95

300Mbps Mini 802.11n USB 2.0 Wireless Network Adaptor

NEW 2011

A discreet yet powerful way to add 802.11n wireless capability to your computer. With a theoretical max transfer rate of 300Mbps and the added reach that is part of the 802.11n standard this unit is a secure, sleek and convenient networking upgrade for the home or office.

$29.95

- Compatible with Windows 2000, XP, Vista, Windows 7, Linux and MAC OSX
- Dimensions: 58(L) x 26(W) x 9(H)mm

YN-8307

USB CHARGED BOOK READING LIGHT

Stylish book light which recharges via a USB port. Flexible positioning, 180° rotation and weighs 35g. Supplied with two brackets, one for clipping onto your notebook monitor, the other for attaching to a book. Comes in black colour.

NEW 2011

$9.95

- Measures: 110(H) x 35(W) x 15(D)mm (less clip)

ST-2817

Security

7" LCD MONITOR SURVEILLANCE KIT WITH 2 X CMOS CAMERAS

Simple, cost-effective surveillance solution for small scale indoor applications such as shops and small offices. Powered from one plugpack, all power and video is run along a single integrated cable. The LCD monitor has an audio input to add a microphone if required. Kit contains: 7" LCD monitor, 2 x CMOS colour cameras, 2 x 18m cables, mains adaptor, remote control, & mounting brackets.

- 1/4" CMOS sensor
- 420TV Lines
- Dimensions Camera: 85(L) x 46(Dia)mm
  Monitor: 186(W) x 86(H) x 30(D)mm

QC-3640 WAS $199.00

$179.00 SAVE $20.00

MINI CCTV 420 TV LINES CAMERAS

Ideal for use in retail stores, home security, remote monitoring or covert applications. All feature adjustable focus lens and composite video output with audio, which can feed into the AV inputs on any DVR or TV. Requires a 12VDC regulated power supply. Three models to choose from.

- Sensor: 1/3" SHARP
- Resolution:420 TV Lines
- Power required: 12VDC

SHARP SENSOR INSIDE

Mini Colour CCD Camera

- Lens: 3.6mm
- Dimensions: 36(W) x 36(H) x 15.9(D)mm

QC-3690 $64.95

Mini Colour Pinhole CCD Camera

- Lens: 3.7mm
- Dimensions: 36(W) x 36(H) x 15.9(D)mm

QC-3692 $69.95

Mini Colour CCD Camera with IR

FROM $64.95

- Lens: 3.6mm
- Dimensions: 36(W) x 36(H) x 15.9(D)mm

QC-3694 $69.95

DUMMY SPEED DOME CAMERA

NEW 2011

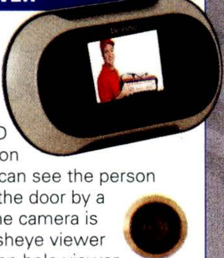
Visual deterrent is one of the most effective way of guarding your property. This realistic looking speed dome camera mounts on your walls or eaves. It has a blinking LED which adds more realism which is powered by 2 x AA batteries (not included).

$24.95

- Measures: 130(Dia)mm x 252(H)mm

LA-5330

2.5" LCD ELECTRONIC DOOR PEEP HOLE VIEWER



Eliminate the small and distorted fisheye view that a traditional door peep hole provides with our electronic door peep hole viewer. With its big 2.5" LCD screen and a built in distortion compensation feature, you can see the person clearly on the other side of the door by a simple press of a button. The camera is no bigger than an original fisheye viewer and looks the same as a peep hole viewer from the outside. Simple to install without compromising door security. Comes complete with an installation tool and AA batteries.

$149.00 SAVE $50.00

- Measures: 146(W) x 90(H) x 30(D)mm

QC-3267 WAS $199.00

8 INCH VIDEO DOORPHONE WITH IMAGE CAPTURE

Automatically captures an image or video clip of visitors when the doorbell button is pressed, allowing you to positively identify visitors before you let them in and give them the third degree over the intercom if necessary.

The ideal way to keep an eye on welcome and possibly not-so-welcome visitors.

- Weatherproof colour camera
- 8.4" HD TFT-LCD colour monitor
- Power Supply: 240VAC
- 2 way AV input
- Dimensions: 223(L) x 162(H) x 38(D)mm

QC-3618 WAS $349.00

$299.00 SAVE $50.00

MINI CAMERA / DVR KITS

3.5" LCD Camera Kit

Connect power and install the camera where needed. The 3.5" TFT LCD gives real-time video monitoring and the microphone in the camera provides audio either through the speaker in the display unit or via headphone outlet. The LCD unit is able to take two AV inputs, so you can add a second camera if required. Mains plugpack included.

- IR illuminator
- Colour CMOS sensor
- Dimensions: 130(W) x 80(H) x 22(D)mm

QC-8007
WAS $149.00

$129.00 SAVE $20.00

Spare CMOS camera available separately:
QC-8009 $49.00 SAVE $20

Mini DVR Kit with Button-Hole Colour Camera

Capture meetings, conferences or lectures with this high definition video and audio mini DVR kit. Store up to 32GB on an SD card, then allow you to view the video on the 2" TFT LCD colour screen with different buttonhole options so it's completely covert and discreet. Includes a Li-Ion rechargeable battery, charger, AV leads, USB cable and dummy buttons for disguising the camera.

- Approx 10 hours of video on 32GB SD card (not included)
- 128MB flash memory
- 420TV lines camera resolution
- Dimensions DVR: 65(W) x 54(H) x 14(D)mm
  Camera: 22(W) x 34(H) x 15(D)mm

QC-8006 WAS $249.00

$199.00 SAVE $50.00

Mini DVR and Bullet Camera Package

NEW 2011

Record and re-live the thrills of your action sport. Mount the camera and screen on your body, helmet or handlebars using one of the four mounts, then record video and audio to the 256MB built-in memory or to an SD Flash card (1GB - 32GB, not included). Playback on the 2.5" colour screen or output to a larger screen using the AV output. Rechargeable 3.7V 1400mAh battery can be charged via USB or using the supplied AC mains charger, and will provide 180 mins of recording for a 240mins charge time.

$269.00

- Camera: colour CMOS (curly cord extends to 1m)
- Video Format: AVI (MPEG-4)
- AC mains charger, USB driver disc, leather case, camera bracket and mounting hardware, USB lead, AV in/out cable, and manual included
- Measures: Camera: 60(L) x 14(D)mm
  Monitor/Recorder: 75(W) x 55(H) x 20(D)mm

QC-8015

YOUR LOCAL JAYCAR STORE - Free Call Orders: PH 1800 022 888

AUSTRALIAN CAPITAL TERRITORY

Belconnen	Ph (02) 6253 5700
Fyshwick	Ph (02) 6239 1801

NEW SOUTH WALES

Albury	Ph (02) 6021 6788
Alexandria	Ph (02) 9699 4699
Bankstown	Ph (02) 9709 2822
Blacktown	Ph (02) 9678 9669
Bondi Junction	Ph (02) 9369 3899
Brookvale	Ph (02) 9905 4130
Campbelltown	Ph (02) 4620 7155
"NEW" Castle Hill	Ph (02) 9634 4470
Coffs Harbour	Ph (02) 6651 5238
Croydon	Ph (02) 9799 0402
Erina	Ph (02) 4365 3433
Gore Hill	Ph (02) 9439 4799
Hornsby	Ph (02) 9476 6221
Liverpool	Ph (02) 9821 3100
Maitland	Ph (02) 4934 4911
Newcastle	Ph (02) 4965 3799
Penrith	Ph (02) 4721 8337
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Rydalmere	Ph (02) 8832 3120
Sydney City	Ph (02) 9267 1614
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Wagga Wagga	Ph (02) 6931 9333
Wollongong	Ph (02) 4226 7089

NORTHERN TERRITORY

Darwin	Ph (08) 8948 4043

QUEENSLAND

Aspley	Ph (07) 3863 0099
Caboolture	Ph (07) 5432 3152
Cairns	Ph (07) 4041 6747
Capalaba	Ph (07) 3245 2014
Ipswich	Ph (07) 3282 5800
Labrador	Ph (07) 5537 4295
Mackay	Ph (07) 4953 0611
Maroochydore	Ph (07) 5479 3511
Mermaid Beach	Ph (07) 5526 6722
Nth Rockhampton	Ph (07) 4926 4155
Townsville	Ph (07) 4772 5022
Underwood	Ph (07) 3841 4888
Woolloongabba	Ph (07) 3393 0777

SOUTH AUSTRALIA

Adelaide	Ph (08) 8231 7355
Clovelly Park	Ph (08) 8276 6901
Gepps Cross	Ph (08) 8262 3200
Reynella	Ph (08) 8387 3847

TASMANIA

Hobart	Ph (03) 6272 9955
Launceston	Ph (03) 6334 2777

VICTORIA

Cheltenham	Ph (03) 9585 5011
Coburg	Ph (03) 9384 1811
Frankston	Ph (03) 9781 4100
Geelong	Ph (03) 5221 5800
Hallam	Ph (03) 9796 4577
"NEW" Kew East	Ph (03) 9859 6188
Melbourne	Ph (03) 9663 2030
Ringwood	Ph (03) 9870 9053
Shepparton	Ph (03) 5822 4037
Springvale	Ph (03) 9547 1022
Sunshine	Ph (03) 9310 8066
Thomastown	Ph (03) 9465 3333
Werribee	Ph (03) 9741 8951

WESTERN AUSTRALIA

"NEW" Joondalup	Ph (08) 9301 0916
Maddington	Ph (08) 9493 4300
Midland	Ph (08) 9250 8200
Northbridge	Ph (08) 9328 8252
Rockingham	Ph (08) 9592 8000

Arrival dates of new products in this flyer were confirmed at the time of print. Occasionally these dates change unexpectedly. Please ring your local store to check stock details. **Prices valid from 24th August to 23rd September 2011.** All savings are based on original RRP

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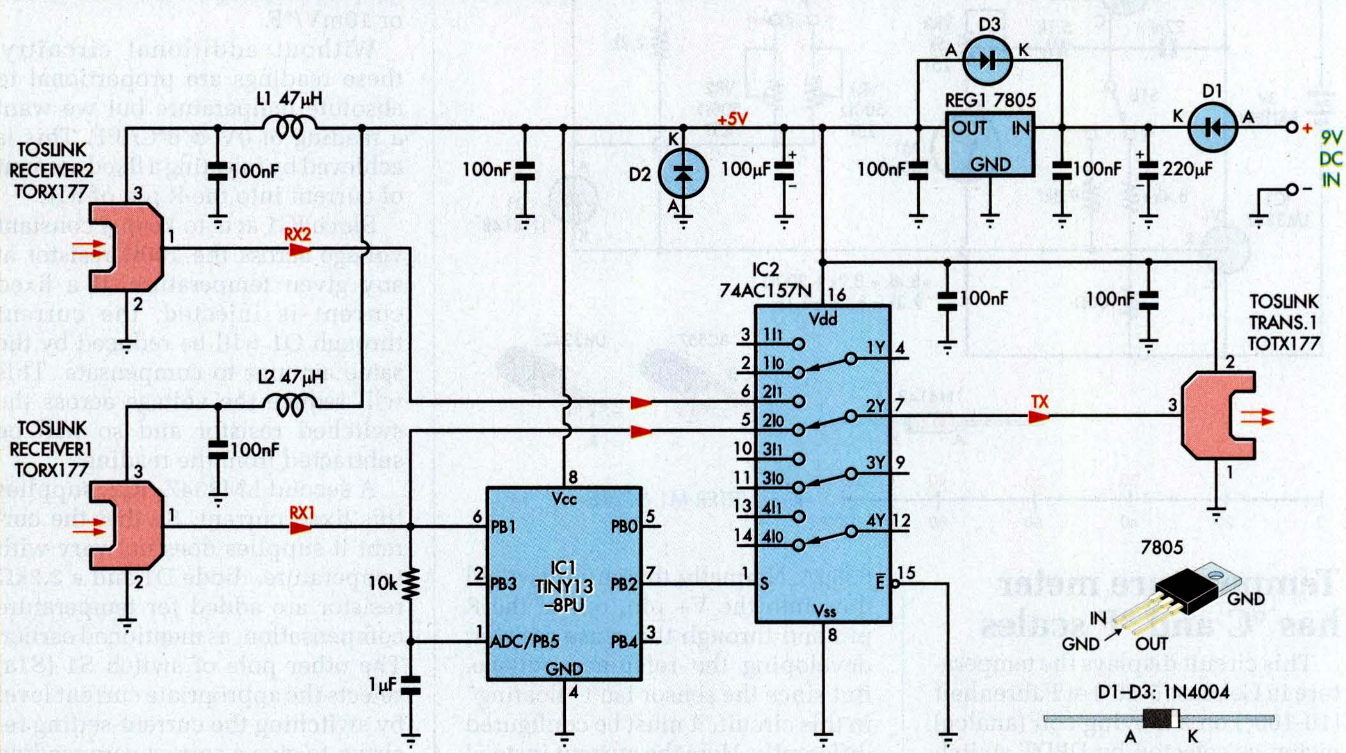
Jaycar Electronics
Better, More Technical

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.



Automatic TOSLink digital audio switcher

This circuit lets you add another TOSLink input to your home theatre system. While passive optical TOSLink combiners are available, they don't work if both TOSLink transmitters are active at the same time. Even if only one is active at a time, these devices can degrade the signal, causing audible clicks and pops.

This automatic switcher instead converts the optical signal to an electrical signal and so does not suffer from these problems. It works as long as the connected devices do not transmit signal data while they are stopped (but it's OK if they leave the transmitter LED on).

The incoming TOSLink optical signals are received by two fibre optic receivers (Receiver1 and Receiver2). The resulting square-wave signals pass to pins 5 & 6 of IC2, a 74AC157 quad 2-way multiplexer IC. Its pin 1 voltage determines which signal is sent to output pin 7; if pin 1 is low then it is the signal at pin 5, from Receiver1. If the pin 1 voltage is high, the selected input is pin 6, from Receiver2.

Whichever signal is selected, it then passes to TOSLink Transmitter1, which is connected to the home-theatre receiver input via another optic fibre cable.

The input to select is determined by an ATTiny13 microcontroller (IC1). When data is present from a receiver, the average output voltage level is around 2.5V (since its output is a high-frequency square-wave). When there is no data present, the average voltage level will be either 0V or 5V, depending on whether the transmitter LED is on or off.

To distinguish between these states, IC1 effectively operates as a window comparator. The data from Receiver1 is low-pass filtered using a 10kΩ resistor and 1μF capacitor and is then applied to pin 1, the ADC0 input. IC1 digitises this voltage. If it is between 1-4V, that indicates there is data present at Receiver1's output and so the micro sets its PB2 output (pin 7) low, selecting this. Otherwise, PB2 goes high and the other input is selected instead.

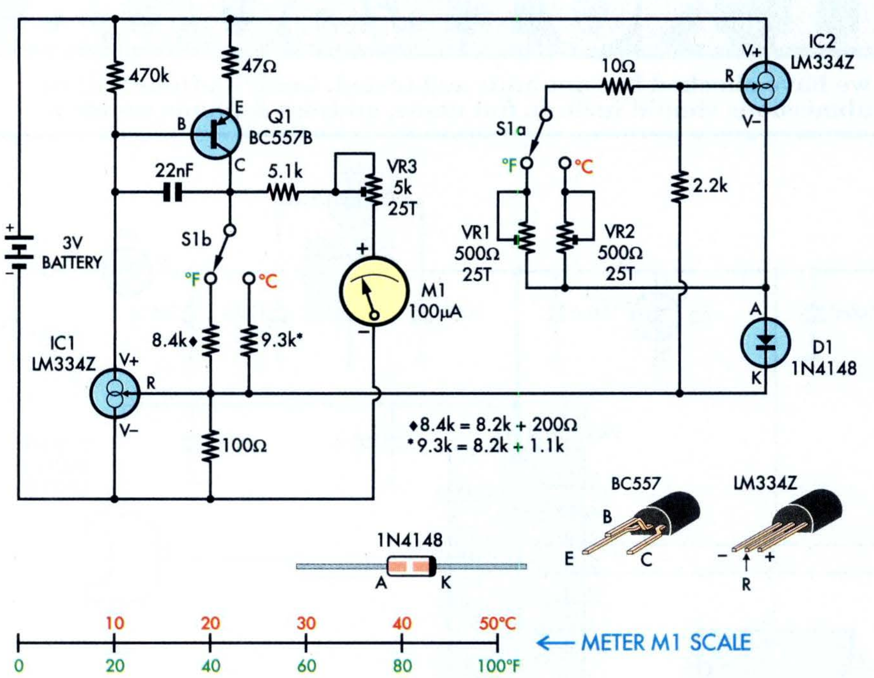
A 5V rail to power the TOSLink receivers and transmitters and both ICs comes from linear regulator REG1, which is fitted with protection diodes and bypass/filter capacitors. It is fed from a 9V DC plugpack via reverse polarity protection diode D1.

The power supply for Receiver1 and Receiver2 is further smoothed by separate LC filters, so that noise from the other ICs doesn't interfere with their operation.

The software for IC1 is available for download from the SILICON CHIP website (toslink_audio_switch.zip).

Greg Radion,
Seaford, Vic. ($50)

Editor's note: IC1 could be replaced by an LM339 configured as a window comparator, with resistors to generate the 1V/4V thresholds and a pull-up resistor at its output. Note also that this circuit requires TOSLink receivers and transmitters designed for 5V operation.



Temperature meter has °C and °F scales

This circuit displays the temperature in Celsius (5-50°) or Fahrenheit (10-100°) on a moving coil (analog) meter, as selected by DPDT switch S1. An LM334Z current-source IC is used as the temperature sensor. A digital voltmeter could also be used to display the temperature reading if desired (in this case, replace the 9.3kΩ resistance with a 4.65kΩ resistance for 10mV/°C).

The LM334Z is normally used as a 3-terminal floating current source, with a single resistor setting the desired current from 1µA to 10mA. This resistor connects between the R and V- terminals and the IC varies the transconductance between the V+ and R terminals to maintain 63.8mV across this resistor at 25°C.

This reference voltage is directly proportional to the absolute temperature, varying by 214µV/°K (214µV/°K x 298.15°K (25°C) = 63.8mV). This variation can be cancelled by adding a diode and resistor, giving a true constant-current source, but these components are not used in this application because the requirement is for the LM334Z to operate as a temperature sensor.

The 100Ω resistor sets IC1's current at 25°C to 63.8mV ÷ 100Ω = 638µA. Normally, this current would flow into the V+ pin, out of the R pin and through the sense resistor, developing the reference voltage. But since the sensor isn't "floating" in this circuit, it must be configured differently. Here the current instead flows through PNP transistor Q1 until ultimately passing through the 100Ω sense resistor.

IC1 controls Q1 by pulling current from Q1's base into its V+ terminal. As IC1 increases its transconductance, this also increases Q1's base current and hence the voltage across the sense resistor increases. The reverse is also true and so the negative feedback operates as normal.

The 470kΩ resistor ensures the required minimum 1µA through IC1 and the 47Ω resistor provides a small amount of local feedback for Q1. The 22nF "Miller" capacitor slows changes in Q1's base voltage and stabilises the circuit.

The voltage across the 100Ω resistor can be multiplied simply by inserting a higher-value resistor between Q1's collector and IC1's R pin. Since virtually all the current that flows through the 100Ω resistor must also flow through this second resistor, the voltage across it is directly proportional and determined by the ratio of the two resistors.

When S1 is set for a Celsius reading, the second resistance value is 9.3kΩ and so the voltage across it varies as 214µV/°K x 9.3kΩ ÷ 100Ω = 20mV/°C. When set to Fahrenheit, the resistance is instead 8.4kΩ giving 214µV/°K x 8.4kΩ ÷ 100Ω = 18mV/°K or 10mV/°F.

Without additional circuitry, these readings are proportional to absolute temperature but we want a reading of 0V @ 0°C/0°F. This is achieved by injecting a fixed amount of current into the R pin of IC1.

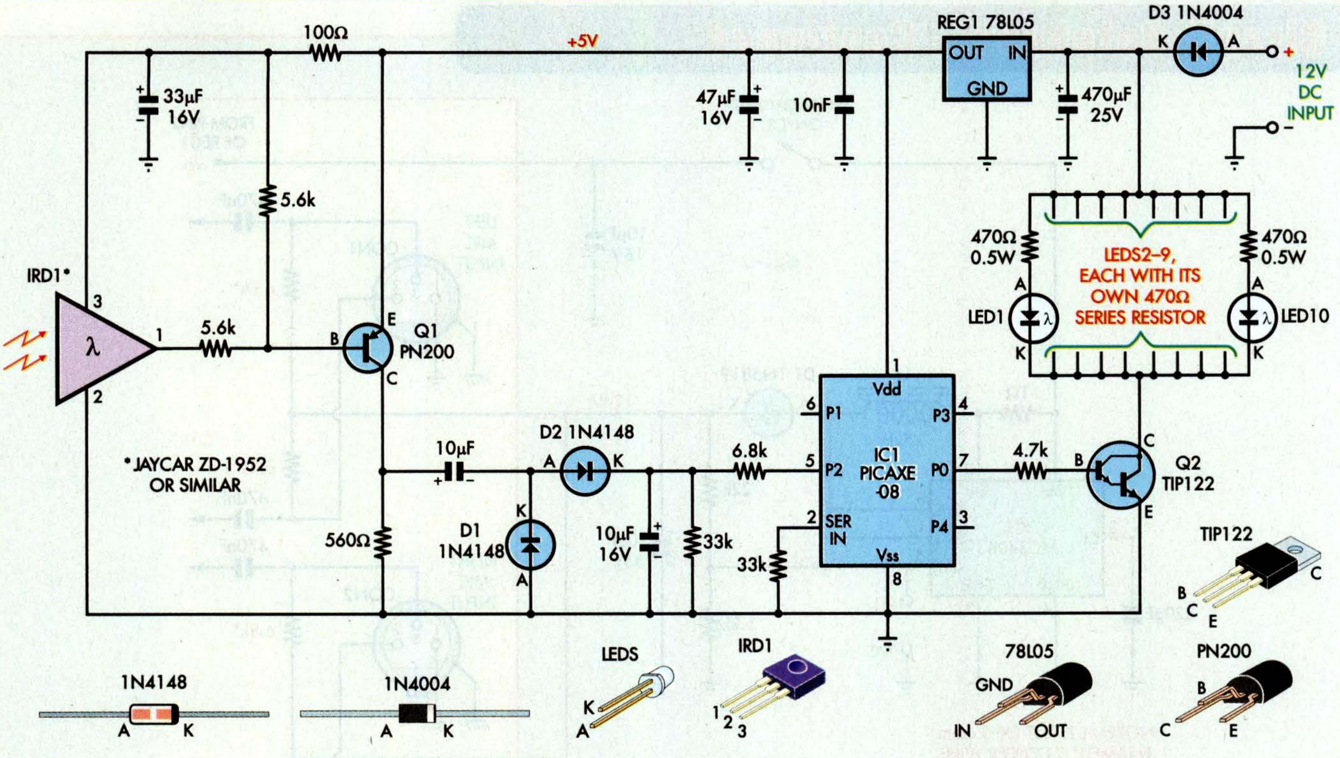
Since IC1 acts to keep a constant voltage across the 100Ω resistor at any given temperature, if a fixed current is injected, the current through Q1 will be reduced by the same amount to compensate. This will reduce the voltage across the switched resistor and so will be subtracted from the reading.

A second LM334Z, IC2, supplies this fixed current. So that the current it supplies does not vary with temperature, diode D1 and a 2.2kΩ resistor are added for temperature compensation, as mentioned earlier. The other pole of switch S1 (S1a) selects the appropriate current level by switching the current-setting resistor, to give a correct zero reading for both scales.

The temperature-related voltage appears between Q1's collector and IC1's R pin. However, the meter is connected between Q1's collector and ground so that the current flowing through it will not affect the reading. This means that the minimum reading is around 64mV due to the voltage across the 100Ω resistor.

This voltage represents an error in the reading, which can be partially cancelled by adjusting IC2 to inject additional current to compensate. Even so, the meter can never zero. If a digital meter with a very high impedance is used (say, 10MΩ), its negative end could potentially be connected to IC1's R pin to eliminate this offset.

To calibrate the unit, adjust VR1 until 548µA flows from the battery into IC2 (measure using a DMM connected in series between them and set to microamps mode). Then switch to Fahrenheit mode and adjust VR2 for 587µA using the same method. M1 can then be trimmed using VR3 so that the correct ambient



PICAXE infrared remote switch for decorative LED light

This circuit came about as a result of making a decorative light out of 10 silk lanterns purchased in Vietnam. It uses 10 high-intensity white LEDs, a 12V plugpack and 10 470Ω resistors. Since a GPO was not readily accessible, it was decided to switch it on via IR remote control.

IRD1 receives the 38kHz pulses from virtually any infrared remote control and these are buffered by PNP transistor Q1. The resulting signal is then rectified with a diode pump, which brings pin 5 of PICAXE microcontroller IC1 high after several pulses from IRD1. This delay helps to reject spurious triggering caused by random pulses of infrared light or noise from IRD1's internal circuitry.

The micro is set up so that when pin 5 (P2) stays high for at least six seconds, pin 7 (P0) is toggled, turning NPN Darlington transistor Q2 on or off. Q2 switches 12V power to the lamp. The long delay is incorporated so that normal intermittent infrared remote control use won't accidentally trigger the lantern. To turn the lamp on or off, the remote is pointed at the lamp receiver and any button is held down for at least six seconds.

The 33kΩ resistor across the 10µF capacitor discharges it in around 330ms so that several short bursts of infrared won't inadvertently trigger the circuit.

Linear regulator REG1 and its associated bypass/filter capacitors is used to derive a +5V rail for IRD1 and IC1 from the nominal 12V supply. Power for IRD1 is further filtered by a 100Ω resistor and 33µF capacitor, as its internal high-gain amplifier is sensitive to supply noise. Diode D3 provides reverse polarity protection for the entire circuit.

When the lamp is on, each LED draws around 20mA for a total of 160mA. This basic circuit could have other uses including mains switching with Q2 driving a mains-rated relay with a 12V coil (in this case the usual wiring, insulation and earthing safety rules must be observed).

Paul Walsh,
Montmorency, Vic. ($60)

Software Listing

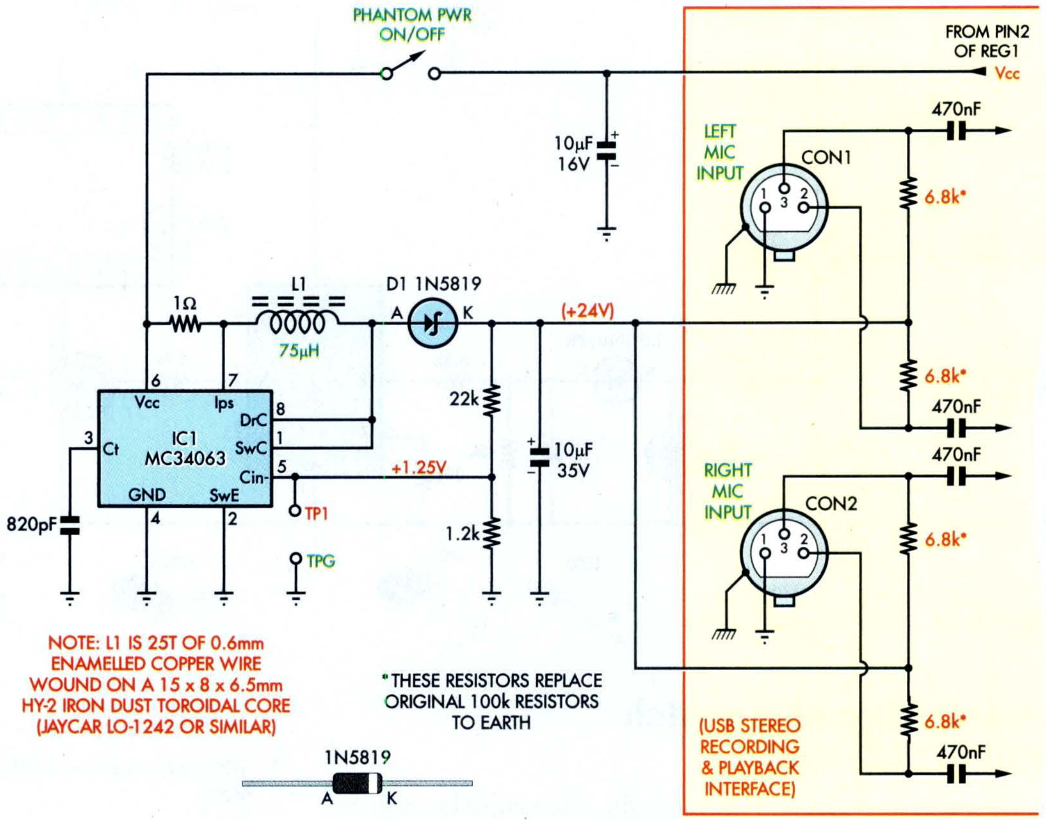
```
'PICAXE code for IR Switch
Main:
low 0
b0=0
if pin2=1 then Lightcheck
goto main

lightcheck:
b0=0
for b0=0 to 120
pause 50
if pin2=0 then lightcheck
next b0
toggle 0

Light:
wait 5
goto lightcheck
```

temperature is displayed (as measured with a reference thermometer).

Malcolm Sharp,
Berala, NSW. ($70)

Editor's notes: a higher gain transistor for Q1 (eg, BC559C) will reduce the error introduced by its base current which flows through IC1 and the 100Ω sense resistor only.

Variations in IC1's temperature coefficient and the tolerance of the 100Ω resistor will introduce further inaccuracies but these can be mostly eliminated if that resistor is replaced with a 200Ω or 500Ω multi-turn trimpot wired as a rheostat. This is then adjusted to give correct readings at both ends of the scale.



Phantom power for the USB Recording Interface

Since publication of our USB Stereo Recording & Playback Interface in June 2011, several readers have asked if it would be possible to add a "phantom mic power" circuit to the interface, so that it could be used with balanced electret microphones.

This presents a challenge, as this type of microphone needs a power supply of between 21V and 48V at up to 5mA. Two such microphones would typically need 24V at a combined current of 10mA.

The logical way to generate this voltage from a USB supply line in the USB Recording Interface is to use a simple DC-DC converter. But even with a conversion efficiency of 100%, this would mean it would draw up to 60mA. This is roughly equal to the rest of the interface's circuitry and would take the total current to above 100mA (the maximum allowed for "low-power" USB devices).

With the DC-DC converter circuit shown, the efficiency is about 62%, resulting in a maximum converter current of about 90mA. This gives a maximum total current from the USB line of 150-160mA, which is acceptable provided the USB Recording Interface is connected directly to one of the PC's USB ports (or via a powered external hub).

So while it's not ideal, we're publishing the circuit here for those who particularly want to provide phantom power for balanced electret microphones. It uses an MC34063 controller, with inductor L1 wound on a small iron-dust toroidal core (see circuit for winding details).

The output of the converter is approximately +24V and this is fed via 6.8kΩ resistors to the four "live" input pins of both microphone input connectors, CON1 and CON2. These 6.8kΩ resistors replace the original 100kΩ resistors which were on the front of the Interface PCB, connecting each of these points to ground.

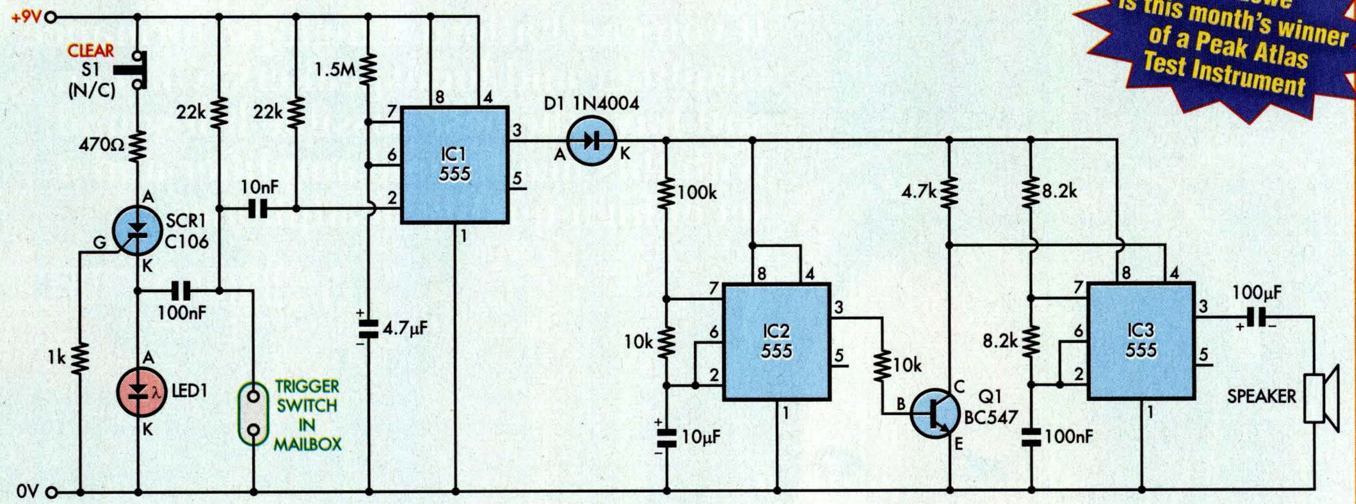
The new 6.8kΩ resistors can be added under the board, with their other ends all connected together so that they can be wired to the converter's output.

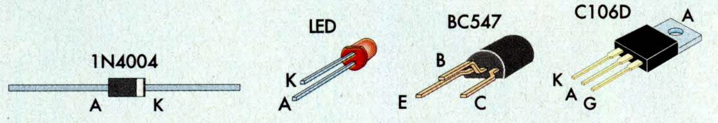
The converter could be assembled on a small piece of Veroboard or matrix board. With L1 flat on the board, the complete assembly should be small enough to fit below the main PCB inside the USB Recording Interface. If switching noise proves a problem, try shielding the converter or mounting it in a separate metal case.

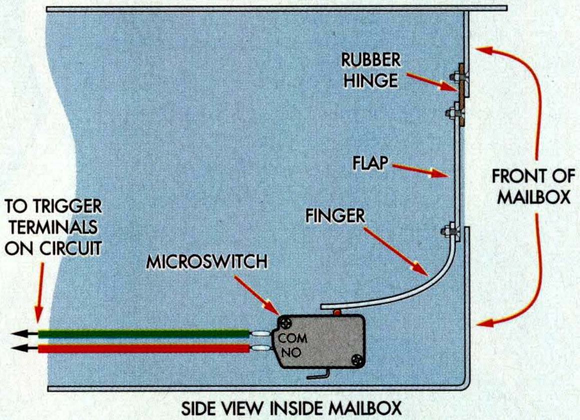
Alternatively, if you don't wish to build a DC-DC converter, you could simply use three 216-type 9V alkaline batteries, connected in series to provide about 27V. This could then be fed to each pair of 6.8kΩ resistors, as described above. No on/off switch would be needed, as current would only be drawn from the batteries when electret microphones were connected to XLR sockets CON1 and CON2.

Apart from the need to replace the batteries every year or two, the only other drawback with this approach is that you'd have to build the USB Recording Interface into a larger case, as there is not enough room in the original case to fit three 9V batteries.

Jim Rowe,
Silicon Chip.







"Postie" annunciator indicates when you have mail

With this unit, you'll know right away when "snail mail" arrives. It's particularly useful if your mailbox is down a long driveway. When mail goes into the box, the unit beeps about six times and lights a LED which stays lit until you reset it.

A microswitch is installed in the mailbox which is triggered by a lever arm attached to a flap over the slot (see adjacent diagram). The "finger" is made of a flexible, springy material such as thin steel or plastic so that the flap can be easily pushed back, triggering the switch, which is wired to the main unit via a length of figure-8 cable.

On the main circuit, one end of the switch is connected to ground while the other end has a 22kΩ pull-up resistor to the positive rail. This end is also coupled to the cathode of SCR1 via a 100nF capacitor. Once the circuit is powered up, this capacitor charges to around 9V.

When the switch contacts close, that pulls the positive terminal of the 100nF capacitor to 0V and so the cathode of the SCR is pulled below its gate. The SCR thus turns on, allowing current to flow through LED1. The 470Ω resistor limits this to around 15mA. Since SCR1 latches on, the LED stays lit until pushbutton S1 is pressed, breaking the current path.

Also, when the trigger switch contacts close, pin 2 of IC1 (a 555 timer) is briefly pulled low via a 10nF coupling capacitor. This starts the timer, which is configured in monostable mode. Its output goes high for about eight seconds, as determined by the 1.5MΩ resistor and 4.7µF capacitor, then it goes low again, ready for another trigger pulse from the switch.

When IC1's output is high, it powers two other 555 timers (IC2 and IC3) via diode D1. These both run in astable mode, ie, as oscillators. IC2 oscillates at around 1.2Hz, with a duty cycle of about 90%, as set by the 10kΩ and 100kΩ resistors and 10µF capacitor.

IC2 drives an inverting amplifier based on NPN transistor Q1, which controls IC3's reset input (pin 4), which is active-low. So when IC2's output is high, IC3 is held in reset. The rest of the time, IC3 oscillates at around 585Hz, as set by the two 8.2kΩ resistors and 100nF capacitor. It drives a small speaker via a 100µF capacitor.

The result is that when the microswitch is triggered, the speaker emits a series of short beeps at 585Hz, 800ms apart.

A. J. Lowe,
Bardon, Qld.

Hifi Stereo Headphone Amplifier, Pt.1

If you can't afford a high-performance amplifier and loudspeakers, you can still have the best possible hifi sound, with this headphone amplifier and a set of high-quality headphones.

By NICHOLAS VINEN

YES, WE KNOW that the Ultra-LD amplifier modules described elsewhere in this issue are "over the top" for many people, especially those living in small home units and those who have to worry about sound levels annoying their neighbours.

But why not listen via a good pair of headphones? Spend a few minutes looking around the internet and you will find all manner of hifi headphone amplifiers that claim to have top-notch performance. In most cases, there is little or no performance data to prove it. Before spending upwards of $1000 on a headphone amplifier we'd want to know just how good it is!

Our new headphone amplifier has a performance virtually the same as our benchmark 20W Class A Stereo Amplifier (May-September 2007). Its distortion at 100mW is lower than that from even the best CD and BluRay players. So essentially what you hear

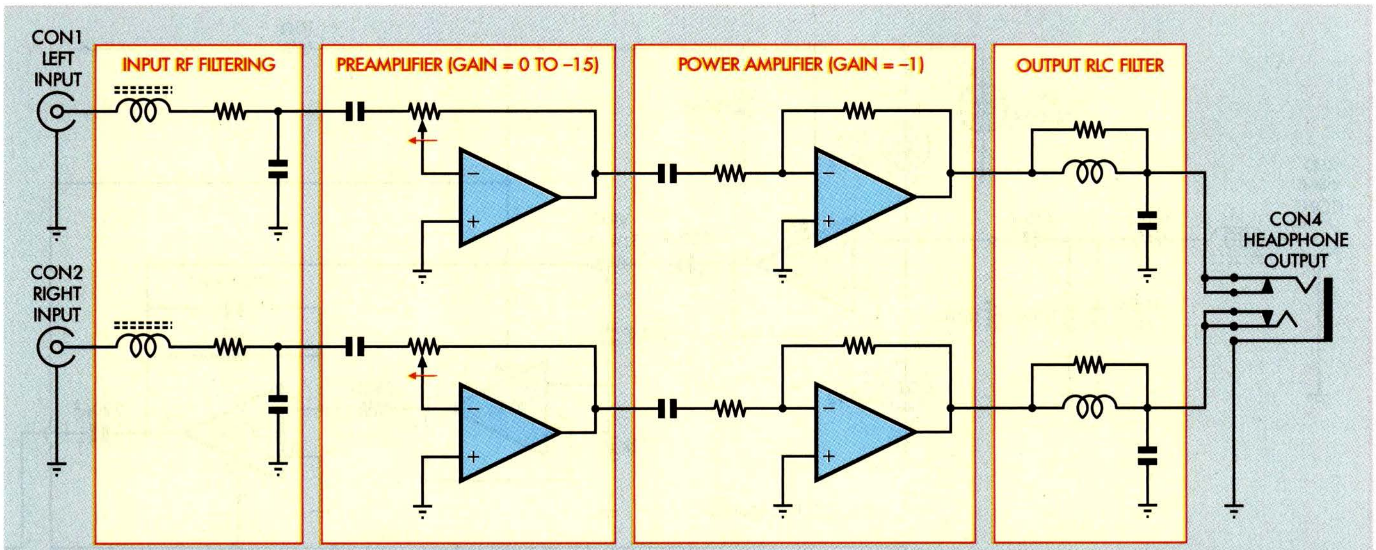


Fig.1: this block diagram shows the basic arrangement of the headphone amplifier. It incorporates RF filtering, a stereo preamplifier, stereo amplifier, output isolation filters and a regulated power supply.

is what is recorded on the CD – no more and no less.

This project does not supersede the Portable Headphone Amplifier for MP3 Players (April 2011) since that one is small, light and battery-powered. That design was intended for use "on the go" and to give much better sound than normally available from iPods and MP3 players.

This new headphone amplifier will also drive 8Ω loudspeakers and has a music power of 4.25W for both channels driven. This is more than adequate if you have reasonably efficient loudspeakers in your study, office or bedroom.

It is housed in a half-size 1U steel case just 210mm wide, 49mm high and 125mm deep and is powered by an AC plugpack (no 230VAC mains wiring). The interior of the case is filled by the PCB which accommodates all the components. There is no other wiring to do; just assemble the PCB, fit it into the case and you're finished.

Circuit features

Fig.1 shows the block diagram of the unit, while Fig.2 shows the complete circuit. It looks huge, doesn't it? That's partly because it shows both channels. It can be split into two sections, with the preamplifiers and power supply on the lefthand side and the power amplifiers on the righthand side.

The preamplifier for each channel is based on three op amps so three LM833 dual op amps are used. The preamp configuration is a classic Baxandall design. The preamplifier is inverting and has a gain range from zero to -15.

The reason for such a wide range in gain is that we have to provide for a large variety of headphone impedances and sensitivities. 8Ω headphones require a much lower voltage swing for the same power compared to 600Ω phones. Driving 8Ω headphones from a CD player (typically 2V RMS) may require a gain of 0.25 or less while using 600Ω phones with a line level signal (0.775V RMS or sometimes less) could require a gain of several times.

The Baxandall preamplifier circuit has the advantage that it varies its gain according to the setting of potentiometer VR1. As a result, the residual noise level is kept low at the low gain settings most commonly required. Like a traditional preamplifier, its gain can go all the way down to zero and up to some fixed number, in this case, 15.

Another advantage of this circuit is its log-like gain curve from a linear potentiometer, which generally have superior tracking compared to log pots. All but the most expensive "log" law potentiometers actually use a dual linear taper and so they don't really have an accurate log response either.

The two power amplifiers on the righthand side of the circuit are loosely based on the 20W Class-A Amplifier

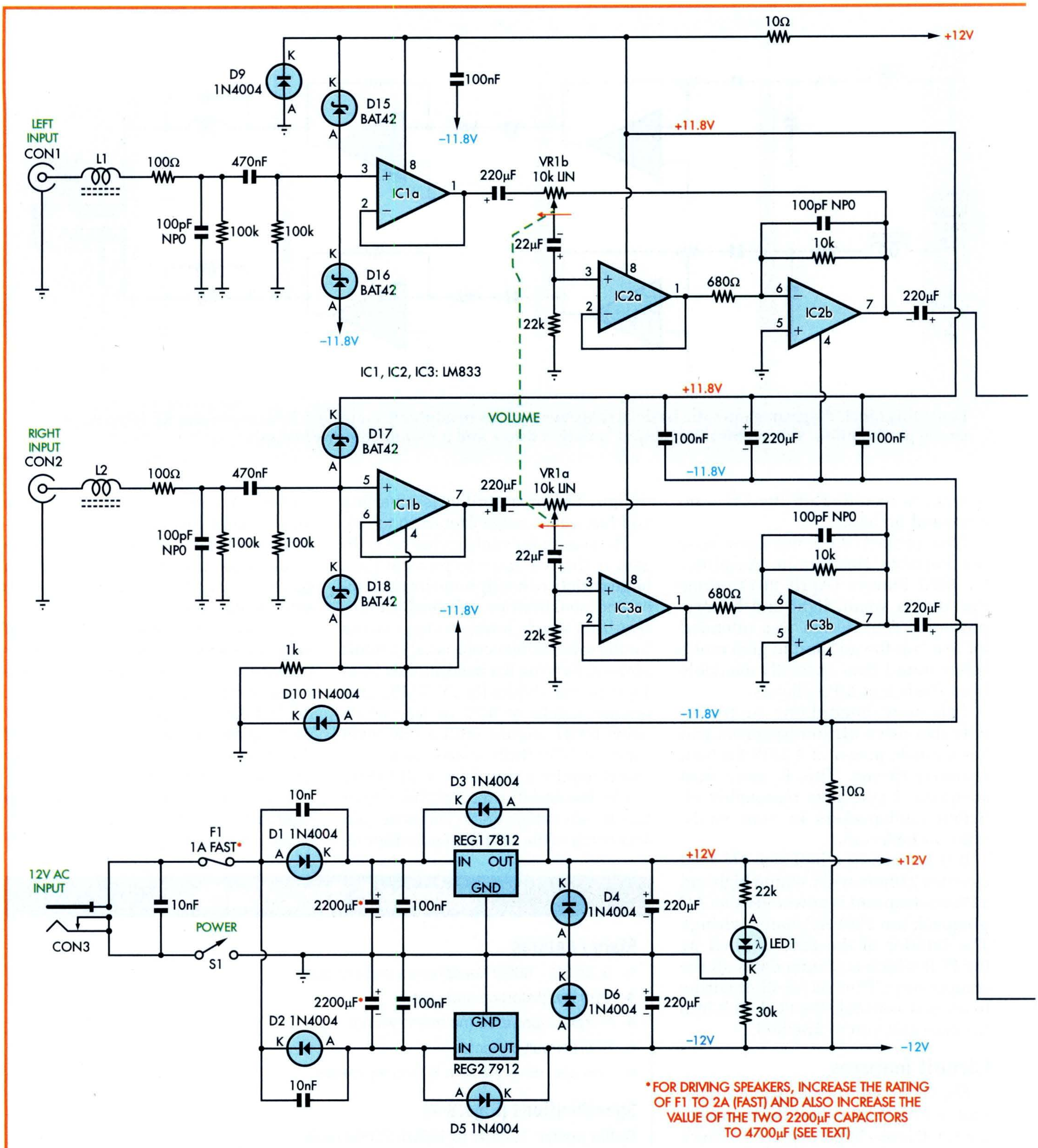
Features & Specifications

Main Features

- Suits 8Ω – 600Ω headphones and ear-buds
- Very low distortion and noise
- Plugpack-powered (no mains wiring)
- Short-circuit protected
- Can also drive efficient 8Ω loudspeakers

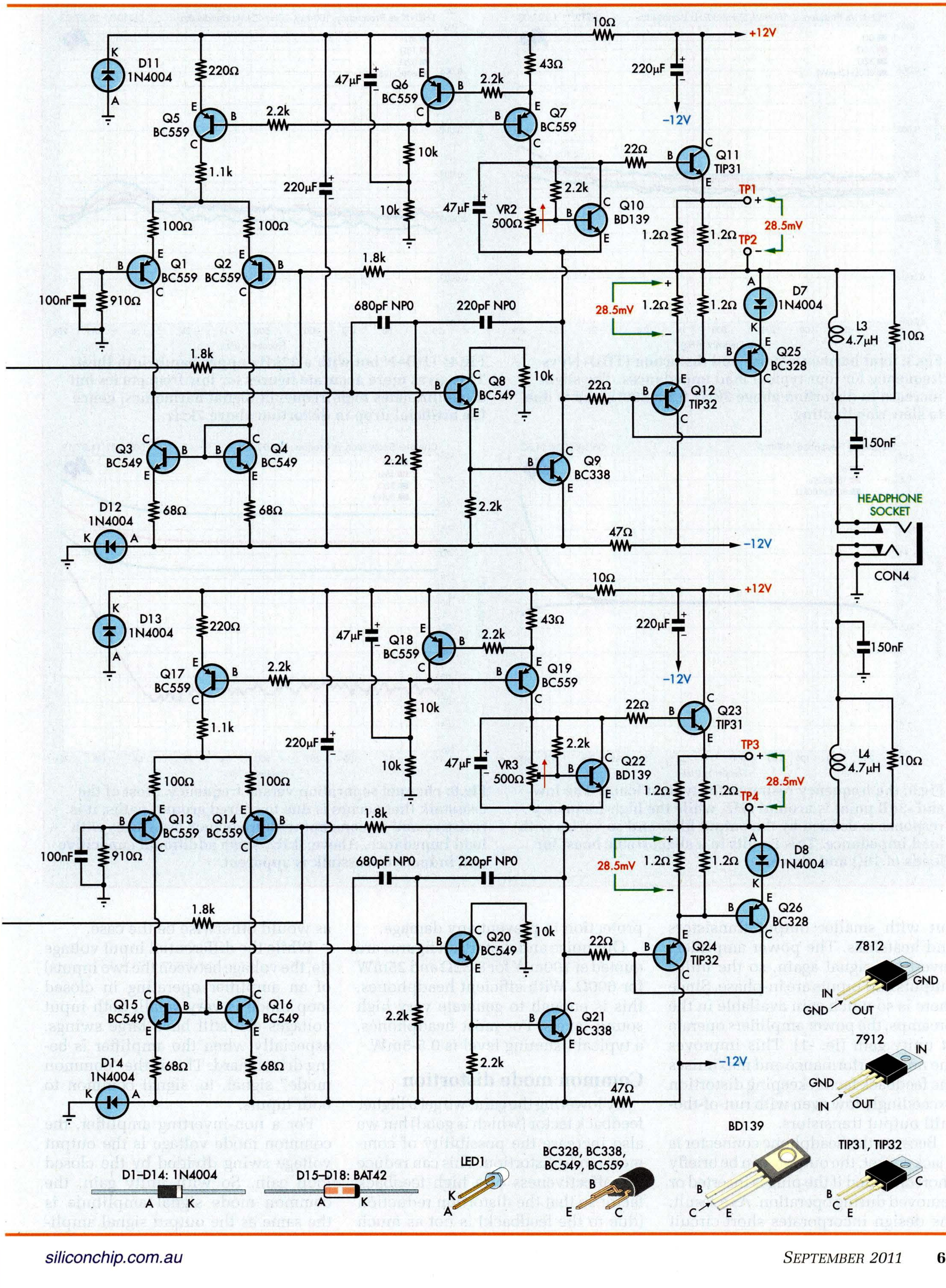
Specifications (Figs.3-7)

Rated power: 100mW (8-100Ω), 25mW (600Ω)
THD: 0.0006% @ 1kHz; 20Hz-22kHz bandwidth
Signal-to-noise ratio: -113dB unweighted; 20Hz-22kHz
Frequency response: ±0.15dB, 20Hz-20kHz
Channel separation: -73dB @ 1kHz
Maximum power: 4.25W (8Ω), 3W (16Ω), 1.5W (32Ω), 800mW (60Ω), 80mW (600Ω)
Class-A power: 18mW (8Ω), 36mW (16Ω), 72mW (32Ω), 80mW (600Ω)
Music power: 4.25W into 8Ω, both channels driven (see text)



SC ©2011 **HI-FI STEREO HEADPHONE AMPLIFIER**

Fig.2: the complete circuit of the Hifi Stereo Headphone Amplifier. The stereo preamplifier section is at upper left and is based on three low-noise dual op amps (IC1-IC3). This stage provides a variable gain of 0-15 depending on the setting of VR1 which functions as the volume control. The two identical power amplifiers are shown at right and these drive the headphones via RLC filters (for stability) and a 6.35mm jack socket. The linear regulated power supply is at lower left and this derives regulated ±12V rails from a 12V AC plugpack.



D11
1N4004
220Ω
Q5
BC559
2.2k
1.1k
47µF
Q6
BC559
2.2k
43Ω
10Ω
+12V
220µF
–12V
Q7
BC559
10k
220µF
10k
22Ω
Q11
TIP31
47µF
VR2
500Ω
2.2k
Q10
BD139
TP1
TP2
28.5mV
1.2Ω
100Ω
Q1
BC559
Q2
BC559
1.8k
100nF
910Ω
680pF NP0
220pF NP0
D7
1N4004
L3
4.7µH
Q25
BC328
Q8
BC549
Q12
TIP32
1.8k
Q3
BC549
Q4
BC549
2.2k
Q9
BC338
150nF
68Ω
D12
1N4004
47Ω
HEADPHONE
SOCKET
CON4
D13
1N4004
Q17
BC559
Q18
BC559
Q19
BC559
Q23
TIP31
VR3
Q22
BD139
TP3
TP4
L4
Q13
BC559
Q14
BC559
D8
1N4004
Q26
BC328
Q20
BC549
Q24
TIP32
Q15
BC549
Q16
BC549
Q21
BC338
D14
1N4004
7812
GND
IN
OUT
7912
BD139
TIP31, TIP32
D1–D14: 1N4004
D15–D18: BAT42
LED1
BC328, BC338,
BC549, BC559

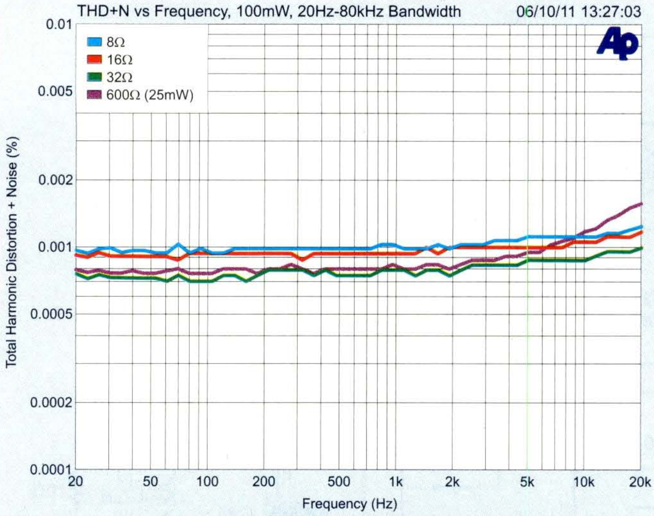


Fig.3: total harmonic noise and distortion (THD+N) vs frequency for four typical load impedances. The slight increase in distortion above 3kHz for a 600Ω load is due to slew rate limiting.

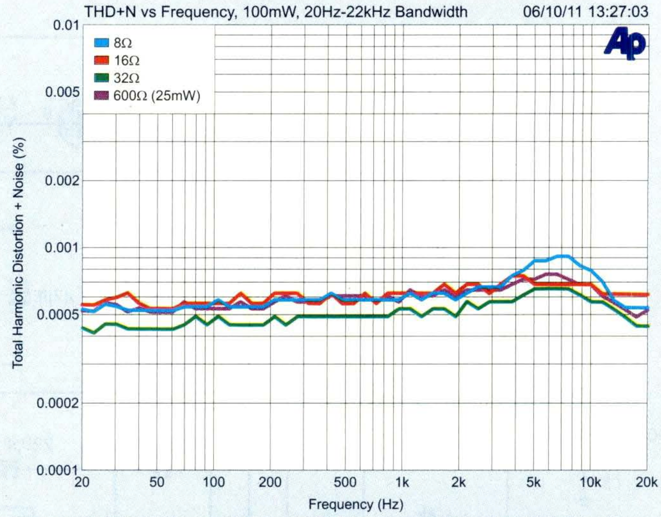


Fig.4: THD+N but with a 22kHz upper bandwidth limit. This gives more accurate figures for low frequencies but also eliminates high-frequency signal harmonics, hence the artificial drop in distortion above 7kHz.

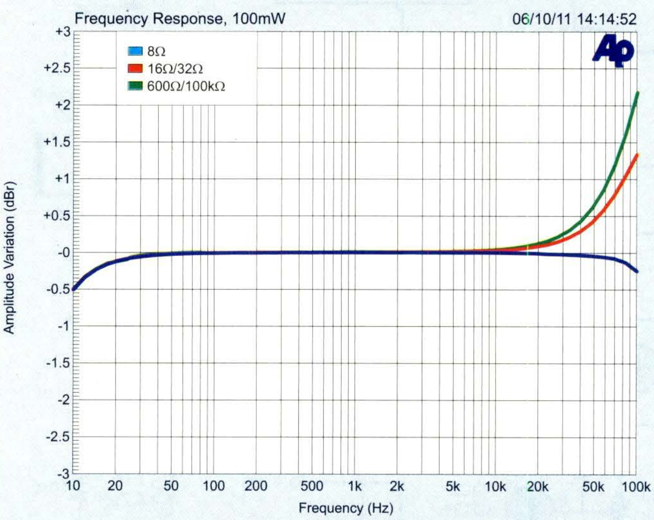


Fig.5: the frequency response for typical loads. The low-end -3dB point is around 3Hz, while the high-frequency response is defined by the output filter and so varies with load impedance. This results in a slight treble boost for loads of 16Ω and above.

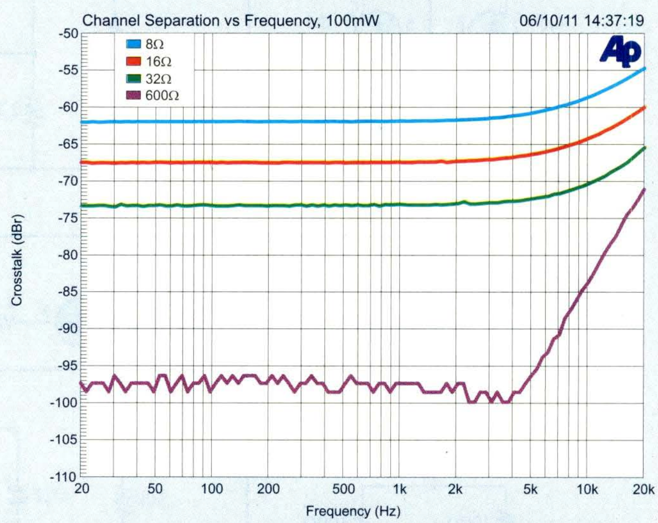


Fig.6: channel separation versus frequency. Most of the crosstalk that occurs is due to shared ground paths; it is resistive and so constant with frequency but varies with load impedance. Above 5kHz, some additional capacitive and inductive crosstalk is apparent.

but with smaller output transistors and heatsinks. The power amplifiers invert the signal again, so the unit's outputs and inputs are in-phase. Since there is so much gain available in the preamps, the power amplifiers operate at unity gain (ie, -1). This improves the noise performance and maximises the feedback factor, keeping distortion exceedingly low even with run-of-the-mill output transistors.

Because the headphone connector is a jack socket, the outputs can be briefly short circuited if the plug is inserted or removed during operation. As a result, the design incorporates short-circuit protection to prevent any damage.

Our noise and distortion figures are quoted at 100mW for 8-32Ω and 25mW for 600Ω. With efficient headphones, this is enough to generate very high sound levels. For most headphones, a typical listening level is 0.5-5mW.

Common mode distortion

By lowering the gain, we get a higher feedback factor (which is good) but we also increase the possibility of common-mode distortion. This can reduce the effectiveness of a high feedback factor so that the distortion reduction (due to the feedback) is not as much as would otherwise be the case.

While the differential input voltage (ie, the voltage between the two inputs) of an amplifier operating in closed loop mode is very small, both input voltages can still have large swings, especially when the amplifier is being driven hard. This is the "common mode" signal, ie, signal common to both inputs.

For a non-inverting amplifier, the common mode voltage is the output voltage swing divided by the closed loop gain. So with unity gain, the common mode signal amplitude is the same as the output signal ampli-

tude, which for our amplifier can be nearly 20V peak-to-peak. Typically, if the common mode signal exceeds 1-2V RMS, common mode distortion can become the dominant distortion mechanism, marring its performance.

This is due to "Early effect" in the input transistors (named after James M. Early of Fairchild Semiconductor). This is caused by the effective width of the transistor base junction varying with its collector-base voltage (see **http://en.wikipedia.org/wiki/Early_effect**).

If the common mode voltage is large enough, the result is modulation of the input transistors' beta and this reduces the overall linearity of the amplifier. These non-linearities cannot be corrected by negative feedback since they occur in the input stage.

The solution is to use an inverting amplifier, as we have in this case. Its non-inverting input is connected to ground and so the inverting input is held at "virtual ground" too, regardless of the output voltage. This configuration has so little common mode voltage that it can't suffer from common mode distortion. To make a power amplifier inverting, we rearrange the feedback network in the same manner as we would with an op amp. In fact, common mode distortion in op amps can be reduced using the same method.

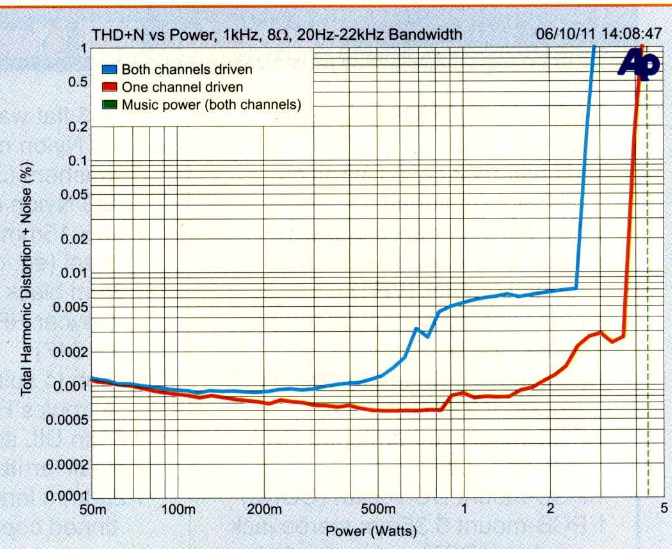
The main disadvantage of the inverting configuration is that the input impedance is low, as determined by the resistor from the signal source to the inverting input. For good noise performance, its value must be low (minimising its Johnson-Nyquist thermal noise). In this case, the preamplifiers provide the amplifiers with a low source impedance, so it isn't a problem.

No driver transistors

If you compare the amplifier circuits to our previously published amplifier designs such as the Ultra-LD Mk.3 or 20W Class-A Amplifier, you will find many similarities.

As with the Ultra-LD Mk.3 amplifier, this design uses 2-pole frequency compensation. As a result, the headphone amplifier has particularly low distortion at high frequencies. For a detailed explanation of the advantages of 2-pole compensation, refer to the article published in the July 2011 issue on "Amplifier Compensation and Stability".

Fig.7: total harmonic distortion and noise versus power with the larger filter capacitors and a 2A plugpack. Music power is 4.25W (both channels driven) but continuous output power is limited by the power supply.



The main difference is that the two output transistors are driven directly from the voltage amplification stage, with no driver transistors in between. In this case, the output current is quite small due to the relatively low power, so we can get away without the driver stage as long as the output transistors have a good beta figure.

In this case, we are using readily available TIP31 (NPN) and TIP32 (PNP) transistors, rated at 3A and 40W each; more than enough for our needs. They have an excellent beta for a power transistor, at around 200 for 100mA and 25°C.

How it works

Let's start with the preamp stages and since both channels are identical, we will just describe the left channel. Any RF signals picked up by the input leads are attenuated by a low-pass filter consisting of a ferrite bead, a 100Ω resistor and a 100pF capacitor. The ferrite bead acts like an inductor to block RF. The signal is then coupled via a 470nF capacitor to pin 3 of op amp IC1a which is configured as a voltage follower. This provides a low source impedance to the preamp gain stages comprising IC2a & IC2b.

IC1a's output is fed to the following stage via a 220µF electrolytic capacitor. This large value ensures good bass response and avoids any distortion that may arise from the typical non-linearity of an electrolytic capacitor.

The signal passes to the non-inverting input of IC2a (pin 3) via volume control potentiometer VR1 and a 22µF electrolytic capacitor. This capacitor ensures there is no DC flowing through VR1, which would otherwise cause a crackling noise when it is rotated.

IC2a buffers the voltage at the wiper of VR1 to provide a low impedance for inverting amplifier IC2b. IC2b has a fixed gain of 14.7, set by the 10kΩ and 680Ω resistors. The 100pF feedback capacitor is there to improve circuit stability and reduce high-frequency noise.

Volume potentiometer VR1 is part of the feedback network from the output from IC2b to the input at the 220µF capacitor (from pin 1 of IC1a). Hence IC2a & IC2b form a feedback pair with the overall gain adjustable by VR1.

When VR1 is rotated fully anticlockwise, IC2b's output is connected directly to VR1b's wiper. Thus IC2b is able to fully cancel the input signal (as there is zero impedance from its output to the wiper) and the result is silence (no output signal) from the preamplifier.

Conversely, when VR1 is fully clockwise, VR1b's wiper is connected directly to the input signal, which is then amplified by the maximum amount (14.7 times) by IC2b. At intermediate settings, the signal at the wiper is partially cancelled by the mixing of the non-inverted (input) and inverted (output) signals and the resulting gain is intermediate.

The way in which this cancellation progresses as VR1 is varied provides a quasi-log law gain curve.

IC1 needs input protection

Because the headphone amplifier may be turned off when input signals

Parts List: Hifi Stereo Headphone Amplifier

1 PCB, code 01309111, 198 x 98mm
1 1U half rack case (Altronics H4995) (optional)
1 12V AC 1A or 2A plugpack
1 10kΩ dual gang linear 16mm potentiometer (VR1)
2 500Ω sealed horizontal trimpots (VR2, VR3)
1 PCB-mount white switched RCA socket (CON1)
1 PCB-mount red switched RCA socket (CON2)
1 PCB-mount DC socket (CON3)
1 PCB-mount 6.35mm stereo jack socket (3PST) with extended pins (Jaycar PS-0190 or equivalent) (CON4)
1 PCB-mount right-angle SPDT mini toggle switch (S1) (Altronics S1320)
2 M205 PCB-mount fuse clips (F1)
1 M205 1A fast-blow fuse (F1)*
6 PCB-mount 6021-type flag heatsinks (Element14 Order Code 1624531; Jaycar HH8504, Altronics H0637)
8 TO-220 insulating washers
6 TO-220 insulating bushes
2 plastic former bobbins (Jaycar LF1062, Altronics L5305)
1 2m length 0.8mm diameter enamelled copper wire
1 25mm length 25mm diameter heatshrink tubing
6 PCB pins
4 M3 x 15mm machine screws
6 M3 x 10mm machine screws
10 M3 nuts
18 M3 flat washers
4 M3 Nylon nuts with integral washers (Jaycar HP0150) or M3 Nylon nuts and washers
1 35 x 15mm section of tin plated steel (eg, cut from a tin can lid)
1 3mm black plastic LED clip (Jaycar HP1100, Altronics H1547)
1 knob to suit VR1 (suggested: Altronics H6213)
3 8-pin DIL sockets (optional)
2 small ferrite beads
1 250mm length 0.7mm diameter tinned copper wire

Semiconductors
3 LM833 dual low noise op amps (IC1-IC3)
1 7812 positive 12V linear regulator (REG1)
1 7912 negative 12V linear regulator (REG2)
2 TIP31 3A NPN transistors (Q11, Q23)
2 TIP32 3A PNP transistors (Q12, Q24)
2 BD139 1.5A NPN transistors (Q10, Q22)
2 BC328 PNP transistors (Q25, Q26)
2 BC338 NPN transistors (Q9, Q21)
6 BC549 NPN transistors (Q3-Q4, Q8, Q15-Q16, Q20)
10 BC559 PNP transistors (Q1-Q2, Q5-Q7, Q13-Q14, Q17-Q19)
1 3mm blue LED (LED1)
14 1N4004 1A diodes (D1-14)
4 BAT42 Schottky diodes (D15-D18) (or use BAT85, Altronics Cat. Z0044)

Capacitors
2 2200µF 25V electrolytic*
11 220µF 25V electrolytic**
4 47µF 16V electrolytic**
2 22µF 16V electrolytic**
2 470nF MKT
2 150nF MKT
7 100nF MKT
3 10nF MKT
2 680pF C0G/NP0 ceramic
2 220pF C0G/NP0 ceramic
4 100pF C0G/NP0 ceramic

Resistors (0.25W, 1%)

4 100kΩ	2 680Ω
1 30kΩ	2 220Ω
3 22kΩ	6 100Ω
8 10kΩ	4 68Ω
10 2.2kΩ	2 47Ω
4 1.8kΩ	2 43Ω
2 1.1kΩ	4 22Ω
1 1kΩ	6 10Ω
2 910Ω	8 1.2Ω (1% or 5%)

Notes
* For driving speakers, upgrade the plugpack to 12V AC 2A, the fuse to 2A and the power supply capacitors to 4700µF 25V (diameter ≤16mm, height ≤30mm, eg, Futurlec C4700U25E105C).
** Low ESR 105° types can be used if their diameter is no more than 6.3mm for 22µF/47µF and 8mm for 220µF.

are present, IC1's input transistors can be subjected to relatively high voltages; up to 2.5V RMS or maybe 7V peak-to-peak. This will not damage IC1 immediately but over many years, it could degrade the performance. This is because normally very little current flows through the op amp inputs and so the metal traces within the IC are thin. If enough current passes through the inputs (5mA or more), "metal migration" can cause degradation and ultimately failure.

For that reason we have included small-signal Schottky diodes D15 & D16 to protect pin 3 of IC1a (and D17 & D18 for pin 5 of IC1b) when the unit is switched off but a large signal is applied. They clamp the voltage at that input to within ±0.3V of the supply rails under normal conditions, preventing current flow through the op amp input transistors should their junctions be reverse-biased.

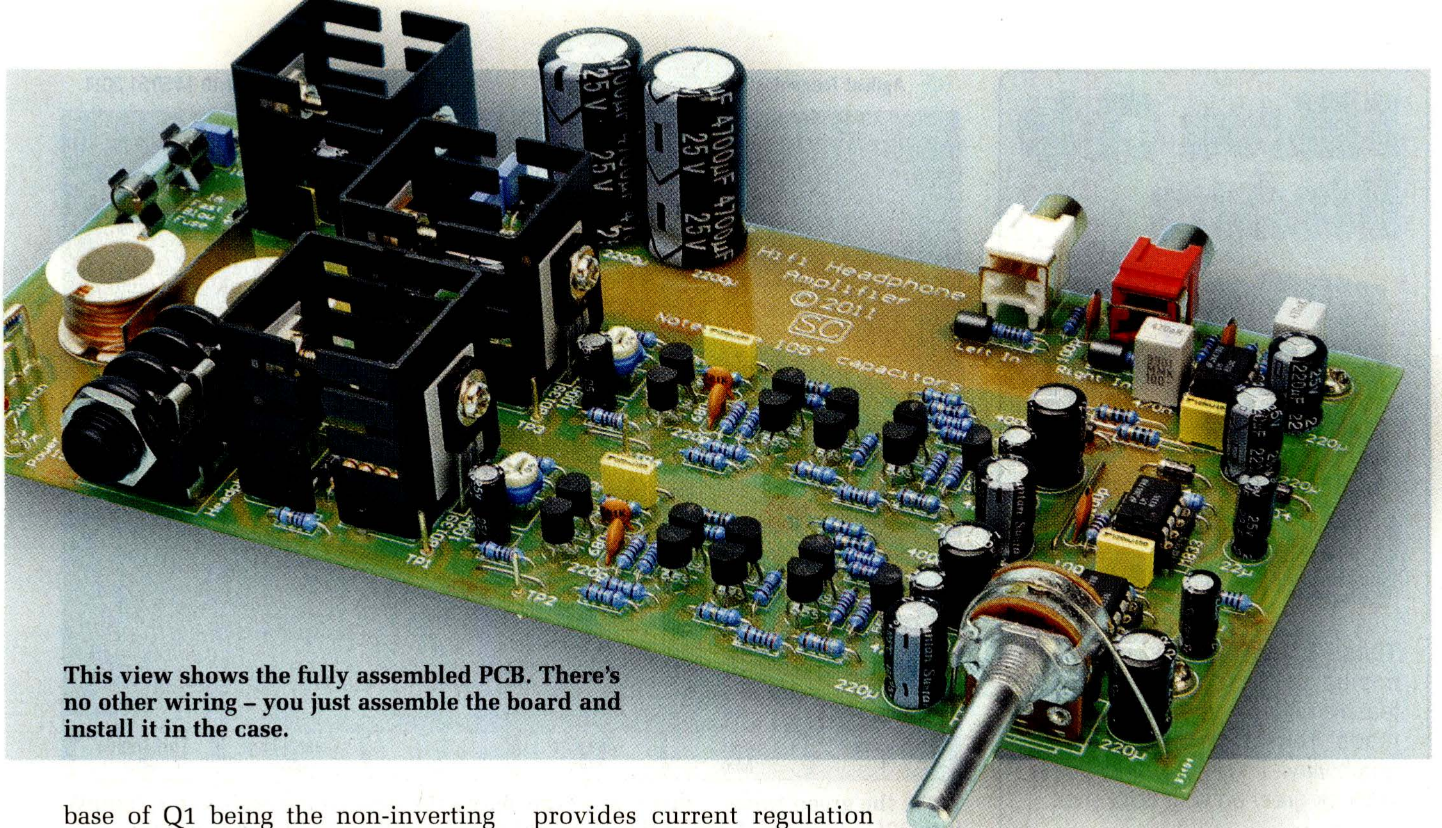
So if the unit is off and the supply rails are zero, the input voltages will be similarly limited to ±0.3V.

The BAT42 diodes have been carefully selected to clamp the op amp input voltages appropriately without having so much leakage current that they will introduce distortion into the signal (Schottky diodes normally have a much higher reverse leakage current than standard silicon diodes). For more information on protecting op amp inputs, see Analog Devices tutorial MT-036, "Op Amp Output Phase-Reversal and Input Over-Voltage Protection".

We also tested BAT85 diodes (Altronics Z0044). These have slightly higher capacitance when reverse-biased (10pF compared to 7pF) and a significantly higher reverse leakage current (400nA at -15V/25°C compared to 75nA). However, testing shows no measurable increase in distortion with these in place of the BAT42s so they are an acceptable substitute.

Amplifier circuit

Low-noise PNP transistors Q1 & Q2 are the differential input pair, with the



This view shows the fully assembled PCB. There's no other wiring – you just assemble the board and install it in the case.

base of Q1 being the non-inverting input to the amplifier and the base of Q2 being the inverting input. Q1's base is tied to ground by a 910Ω resistor (to match the 900Ω source impedance at the base of Q2) and is bypassed by a 100nF capacitor to reduce high-frequency noise.

The signal from the preamplifier is fed to the base of Q2 via a 1.8kΩ feedback resistor, so that the amplifier works in the inverting mode. 1.8kΩ is the lowest value resistance that IC2b can drive in parallel with its own feedback network.

PNP transistor Q5 operates as a 3mA constant current source (0.65V ÷ 220Ω) to feed the Q1/Q2 input pair. Negative feedback for current regulation is provided by another PNP transistor, ie, Q6. It has a bootstrapped collector current sink (two 10kΩ resistors and a 47μF capacitor), so that it operates consistently.

NPN transistors Q3 and Q4 form a current mirror for the input pair, with 68Ω emitter resistors to improve its accuracy. Any difference in the current through Q1 and Q2 must then flow to the base of NPN transistor Q8. So Q1-Q5 form the transconductance stage of the amplifier.

Together, Q8 and Q9 form a Darlington-like transistor, configured as a common-emitter amplifier. PNP transistor Q7 acts as a constant current source for its collector load, sourcing about 15mA (0.65V ÷ 43Ω). Q6 provides current regulation feedback for Q7 as well as Q5.

The 680pF and 220pF capacitors between Q9's collector and Q8's base, together with the 2.2kΩ resistor from their junction to the negative rail, form the 2-pole frequency compensation scheme mentioned earlier. Together, transistors Q7-Q9 are the voltage amplification stage.

V_{BE} multiplier

Between Q7 and Q9 is Q10 which functions as a V_{BE} multiplier to set the quiescent current for the output transistors Q11 & Q12. Q10 is mounted on the back of Q11's heatsink so that its junction temperature tracks the output stage. Thus, its V_{BE} tracks that of the output transistors (Q11 and Q12), so the bias voltage varies to compensate for changing output transistor temperature, keeping the standing current through them more or less constant.

VR2 is used to adjust this current, while the 2.2kΩ resistor prevents the bias from becoming excessive if VR2's wiper goes open circuit, as it may do while it is being trimmed. A 47μF capacitor filters the bias voltage, improving distortion performance when the output voltage swing is large.

The resulting bias voltage is applied between the bases of output transistors Q11 (NPN) and Q12 (PNP) via 22Ω stopper resistors, which prevent parasitic oscillation. Each output transistor has a 0.6Ω emitter resistor (two 1.2Ω resistors in parallel) which helps to linearise the output stage and stabilise the quiescent current.

Current limiting

While it's always a good idea to plug and unplug the headphones while the power switch is off, we can't rely on that and we don't want the output transistors to blow when it happens. Therefore, both Q11 and Q12 are protected against over-current conditions.

Q11 is current-limited because the 15mA current source (Q7) sets a maximum limit for its base current. According to the TIP31 data sheet, at 25-125°C, the maximum collector current will be about 1.25A; well within its safe operating area (SOA) so as long as the short-circuit is brief.

Q12 is more of a concern because Q9 can sink significantly more than 15mA. The 10kΩ resistor at Q8's collector ultimately limits how much current Q9 can sink as follows. Q8's maximum collector current is around (12V - 0.7V) ÷ (10kΩ + 2.2kΩ) = 1mA. Q9's maximum current gain figure is around 165 (according to the BC338 data sheet), so the maximum Q9 can sink is about 165mA. Hence Q9 is a BC338 (a BC549 has a continuous collector current limit of 100mA).

However, if this much current were sunk from Q12's base then it would fully saturate (turn on hard), exceeding its SOA and possibly causing it to fail.

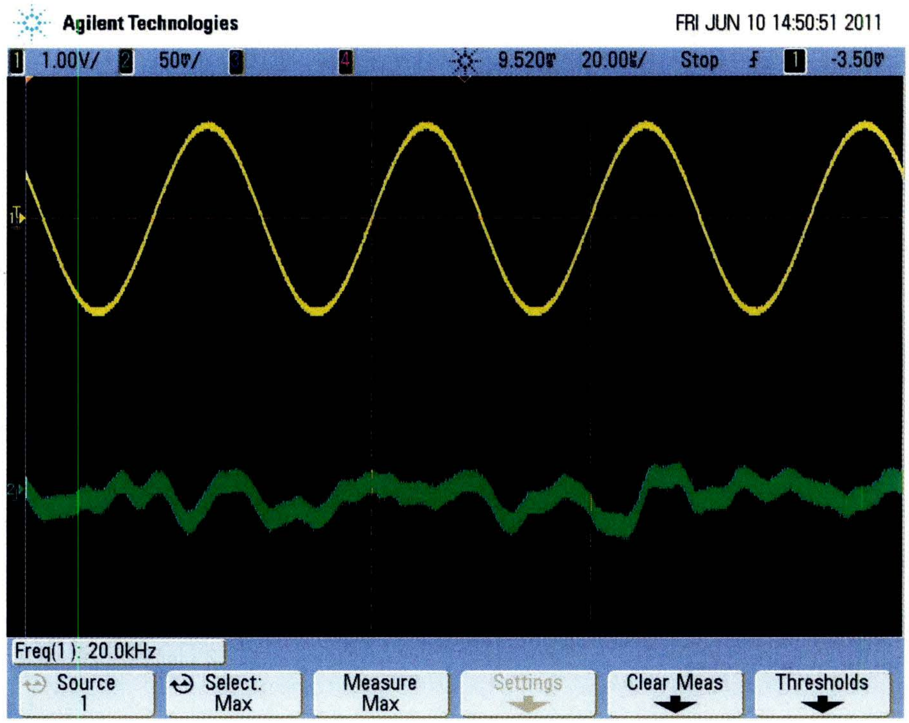


Fig.8: the green trace in this scope grab shows the distortion residual for 100mW into 32Ω at 20kHz. Most of this is actually noise with very little harmonic content. Into lower load impedances (eg, 8Ω) the distortion becomes more apparent and is primarily third harmonic, with some higher harmonics.

Q25 and D7 prevents this. Should the current flow through Q12's collector-emitter junction exceed 2A (within its SOA), the drop across the 0.6Ω emitter resistor exceeds 2A x 0.6Ω = 1.2V.

At this point, Q25's base-emitter voltage increases beyond 1.2V - 0.6V = 0.6V and so Q25 starts to turn on, shunting current around Q12's base-emitter junction and preventing Q12 from turning on harder. Any current sunk by Q9 beyond that necessary for Q12 to pass 2A goes through D7 and Q25 rather than Q12's base-emitter junction.

Output RLC filter

The output filter isolates the amplifier from its load, improving stability. Because this amplifier circuit is already fairly stable (thanks to its simple output stage), we can get away with slightly less inductance than usual (4.7μH rather than 6.8μH or 10μH). We can thus use a thinner gauge wire which is slightly easier to wind, for roughly the same DC resistance.

Ideally, the output filter should be optimised for the expected load impedance but because headphones have such a wide range of impedances, all we can do is compromise and specify an intermediate value. As a result, for higher impedances, the amplifier has a slightly elevated response at above 20kHz (see Fig.5).

For 8Ω operation, there is a very slight roll-off at the high-frequency end of -0.02dB at 20kHz. At around 10-12Ω, the high frequency response will be virtually flat and then for higher load impedances, up to infinity, the gain is as much as +0.13dB at 20kHz. The increase is slightly lower (+0.09dB) for the most common impedances of 16Ω and 32Ω. This deviation is so small as to be imperceptible.

In fact, all our amplifier designs using this type of output RLC filter (devised by Neville Thiele) have such a response with higher than usual output impedances or no load.

Power supply

The 12V AC plugpack plugs into an on-board DC connector (CON3). A 1A fuse protects the plugpack in case of a board fault or overload.

The power switch (S1) is in the ground leg so that the tracks to and from it (near the edge of the PCB) have minimal AC voltage. This eliminates electrostatic radiation, preventing any coupling to nearby signal tracks.

The incoming AC is half-wave rectified by diodes D1 & D2, with three

A half-size 1-unit steel case is used to house the assembled Headphone Amplifier PCB. Pt.2 next month has all the construction and setting-up details.

10nF metal film capacitors for RF and switching suppression. The resulting ±16V rails (nominal; under light load, closer to ±20V) are regulated to ±12V using 3-terminal regulators REG1 & REG2.

So why are we regulating the supply for the whole device rather than just the op amps? Essentially it is because the amplifiers draw so little power when driving headphones that they might as well run off the regulated rails. In addition, the unregulated supply ripple is 50Hz because of the half-wave rectifiers (rather an 100Hz). The regulated supply rails give a lower hum and noise figure.

Switch-on/off behaviour

The circuit has been carefully designed to avoid loud thumps from the headphones when the unit is switched on or off. With a power amplifier, this is usually taken care of with an output muting relay that is also used for speaker protection. Since this amplifier has a low power output and a limited output current, a protection relay isn't necessary.

That is not say that you won't hear any thumps at all. That will depend, in part, on the efficiency of your headphones. However, any thumps you do hear will be very slight.

This has partly been achieved by removing the capacitor which would typically be between Q5's base and the positive rail (as present in the 20W Class-A Amplifier and the Ultra-LD Mk.3). This is not necessary with a regulated supply and if present, it delays the operation of the constant current source controlled by Q5 by several hundred milliseconds at switch-on. This would have caused a loud thump from the headphones had it been retained.

Diodes D11 & D12 (D13 & D14 in the right channel) are also important for proper switch-on behaviour. While the ±12V regulated rails are already protected to prevent the positive rail from going negative and vice versa, the RC filtered supply rails for the early amplifier stages can still suffer from this problem unless extra steps are taken. That's because the filter resistors isolate the capacitors from the clamp diodes D4 & D6.

Without D11 and D12, the positive filtered rail could be briefly pulled negative and this would cause an amplifier output excursion.

The different positive and negative rail filter resistors (10Ω and 47Ω respectively) allow the positive rail to come up more quickly which also helps achieve a clean switch-on. Together, these details allow the amplifiers to operate normally just milliseconds after both filter capacitors are partially charged.

Similarly, diodes D9 & D10 clamp the RC-filtered supply for the op amps in the preamplifier. Without these, the op amp input transistors may become briefly reverse-biased at switch on, causing supply current to flow into the AC-coupling capacitors and again causing a thump to be generated.

Finally, the 1kΩ resistor in parallel with D10 discharges the op amp negative supply rail faster than the positive rail when power is removed. The op amps are prone to oscillation when their supply capacitor is mostly discharged and this can cause a "chirp" at switch-off. With the 1kΩ discharge resistor, this chirp is made very short and often eliminated entirely.

Increasing the output power

While the circuit as presented is capable of driving loudspeakers, a few small changes can usefully increase the power output. If the 2200μF filter capacitors are changed to 4700μF, it increases the current they can supply before regulator drop-out begins.

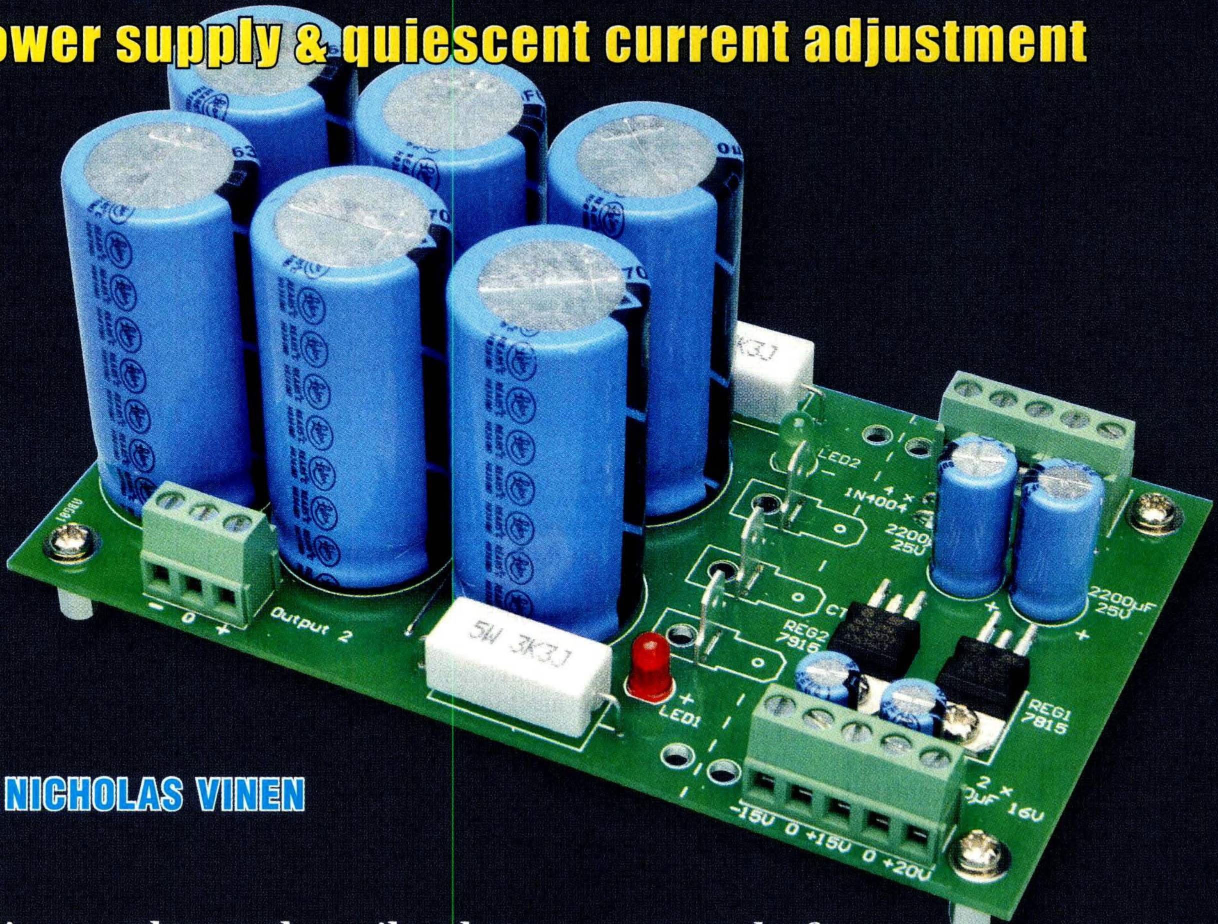
Also, a 12V AC 2A plugpack can be used in combination with a higher rated 2A fuse. This increases the available output power a little more. The THD+N vs power graph (Fig.4) shows the performance when both modifications are incorporated.

Next month

Next month, we shall present the construction details and describe the setting-up procedure. **SC**

Ultra-LD Mk.3 200W Amplifier Module; Pt.3

Power supply & quiescent current adjustment



By NICHOLAS VINEN

This month, we describe the power supply for the new high-performance Ultra-LD Mk.3 amplifier. We also describe how to test and adjust the completed amplifier module and give some details on building it into a metal case.

THE POWER SUPPLY circuit is virtually identical to the Ultra-LD Mk.2 power supply described in September 2008. The changes are in the PCB, which is longer and narrower. This allows it to fit between two amplifier modules mounted on either side of a rack-mount case.

In this configuration, the two DC output connectors line up with the power supply sockets on each amplifier, simplifying the wiring. The AC input terminals face towards the back of the case, where the transformer is normally situated.

Note that if a single power supply is shared between two amplifier modules, the continuous output power is reduced when both channels are driven. However, the music power will not drop so much.

Power supply circuit

Fig.17 shows the circuit details of the power supply. It's based on a toroidal mains transformer (T1) with two 40V windings and two 15V windings.

The two 40V windings are connected together to give 80VAC centre-tapped and this arrangement drives bridge rectifier BR1. This in turn feeds six 4700µF 63V electrolytic capacitors (ie, 14,100µF on each side) to provide balanced ±57V DC rails to power the amplifier.

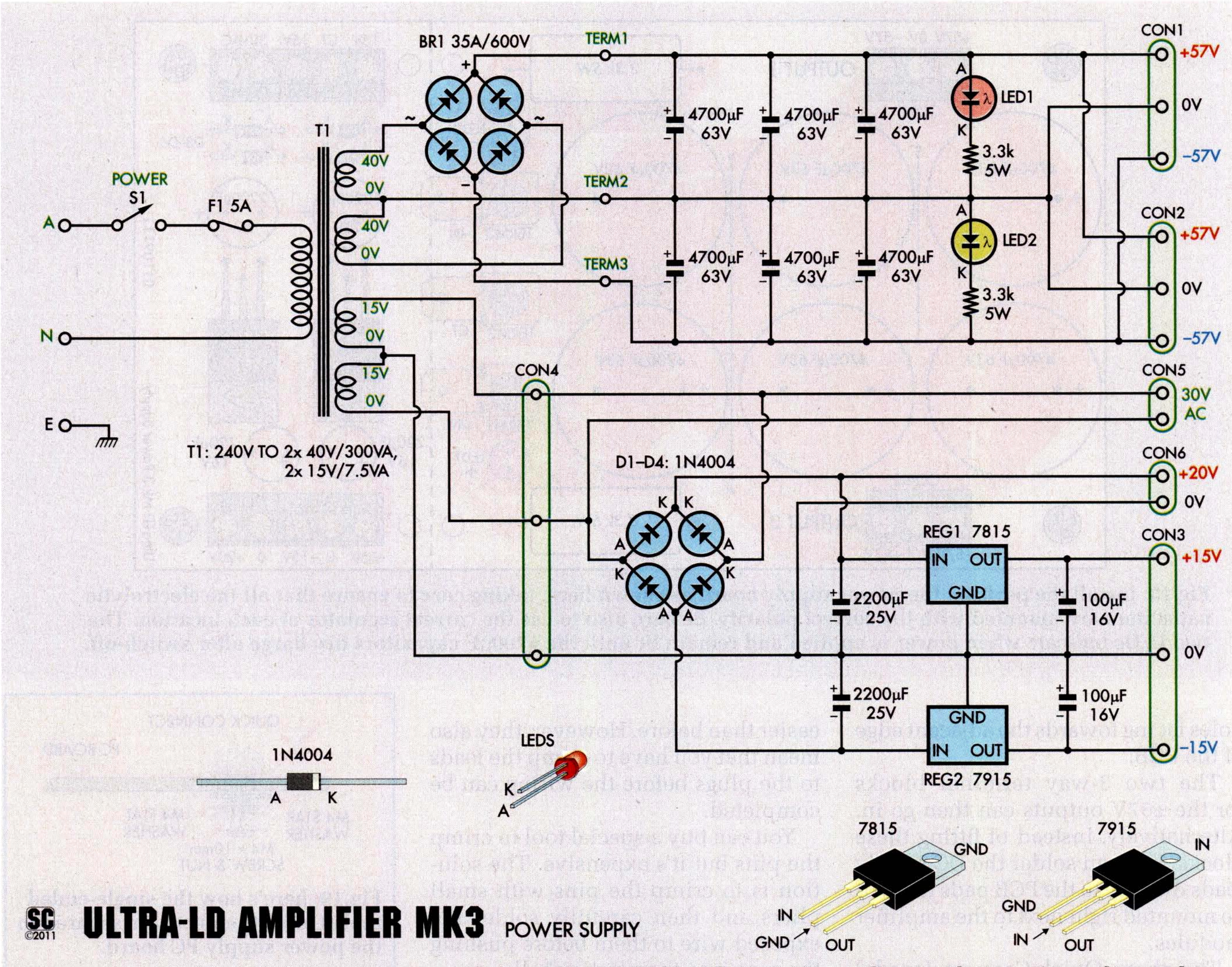


Fig.17: the power supply is based on a toroidal transformer (T1) with two 40V windings and two 15V windings. The two 40V windings drive bridge rectifier BR1 and six 4700µF filter capacitors to produce the ±57V rails.

Two LEDs are connected in series with 3.3kΩ 5W current-limiting resistors across these ±57V supply rails. These serve two purposes: (1) they provide a handy indication that power is present on the supply rails (or when it is not present) and (2) they discharge the filter capacitors when the power is switched off (see warning panel).

The two 15V windings are also connected together to provide 30VAC centre-tapped. These drive bridge rectifier D1-D4 and two 2200µF filter capacitors to derive unregulated rails of about ±20V. These rails are then fed to 3-terminal regulators REG1 & REG2 to derive regulated ±15V supply rails to power a preamplifier module.

The +20V rail is also made available as an output, along with a 30VAC output. The +20V rail is used to power the "Universal Speaker Protector & Muting Module" (described next month), while the 30VAC output is connected to the "AC Sense" input of this module. This latter input is used to quickly disconnect the speaker when the power goes off, to avoid switch-off thumps.

Power supply assembly

Start by checking the PCB (code 01109111) for defects such as hairline cracks or under-etched areas and repair if necessary.

Fig.18 shows the parts layout on the PCB. Begin by fitting the two wire links using 0.71mm or 1mm-diameter tinned copper wire (1mm diameter is better but you may need to enlarge the holes slightly). Follow with the four 1N4004 diodes (D1-D4), orientating them as shown.

Install the two 3-terminal regulators next. You will need to bend their leads down by 90° so that they fit the PCB pads with the tab mounting hole lined up correctly. Attach each regulator to the board using an M3 x 6mm machine screws, shakeproof washer and nut, taking care not to get the two different types mixed up. Solder the leads after the screws have been tightened.

The two LEDs can now be installed. These sit flush against the PCB with the flat side of the lenses orientated as shown on the overlay. Follow these with the two 3.3kΩ 5W resistors. These should be stood off the board by about 2mm, to allow the air to circulate beneath them for cooling (use a cardboard spacer during soldering).

The two 5-way screw-terminal connectors are made by dovetailing 2-way and 3-way blocks together. Be sure to fit these assemblies with the wire entry

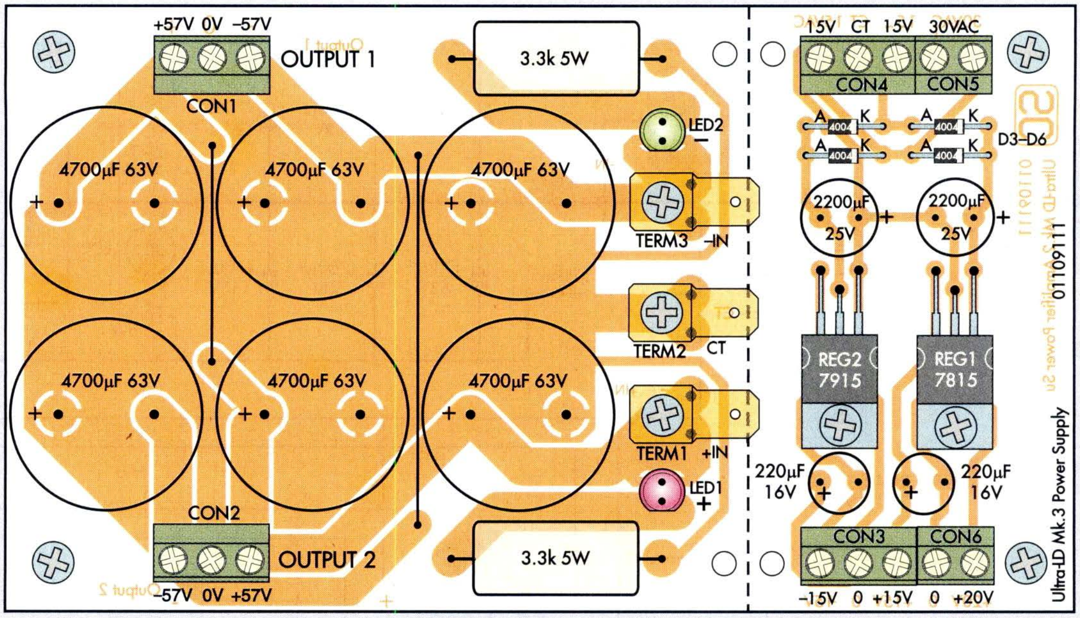


Fig.18: install the parts on the power supply board as shown here, taking care to ensure that all the electrolytic capacitors are mounted with the correct polarity. Be sure also to use the correct regulator at each location. The two LEDs indicate when power is applied and remain lit until the 4700µF capacitors discharge after switch-off.

holes facing towards the adjacent edge of the PCB.

The two 3-way terminal blocks for the ±57V outputs can then go in. Alternatively, instead of fitting these blocks, you can solder the DC supply leads directly to the PCB pads if it will be mounted right next to the amplifier modules.

The three Quick-Connect (spade) terminals are next on the list. If you are using PCB-mount connectors, simply push the pins through and solder them in place. It will take a while to heat the connectors so that the solder will "take". However, be careful not to overdo it, as the solder could "wick" through the hole and onto the spade section.

If you are using 45° chassis spade lugs instead, screw them down tightly using M4 machine screws, nuts and washers – see Fig.19. If you can't get single-ended chassis lugs, cut one side off double-sided lugs.

Finally, fit the electrolytic capacitors, starting with the two 220µF units and finishing with the six large 4700µF units. Be sure to orientate them correctly and make sure that they all sit flush with the PCB.

Cabling

The new plug-in connectors on the power amplifier modules make installing and removing them much easier than before. However, they also mean that you have to crimp the leads to the plugs before the wiring can be completed.

You can buy a special tool to crimp the pins but it's expensive. The solution is to crimp the pins with small pliers and then carefully solder the exposed wire to them before pushing the pins into the plastic shell.

The pins are designed for wires with up to 1.29mm conductor diameter (18AWG) and 3.1mm outer diameter. This is equivalent to heavy-duty hook-up wire and is quite adequate for the power supply wiring. For the speaker wiring, it is perhaps a little thin but it will be sufficient provided the wires to the speaker protection module are kept fairly short.

To wire the plugs, first cut the wires to length and strip about 5mm from the ends. Rest the wire in the channel within the pin, then use small pliers to fold the small metal tabs around the exposed conductor. The larger tabs can then be folded around the insulated portion of the wire and compressed to hold the wire in place.

You can then apply a small amount of solder to each crimped joint, heating it for a few seconds until the solder wicks into it. Try to avoid getting any solder on the outside of the pin or it may not fit into the plastic shell.

When all the pins are crimped and soldered to the wires, push the pins into the rear of the plastic connector shells so that they click into place.

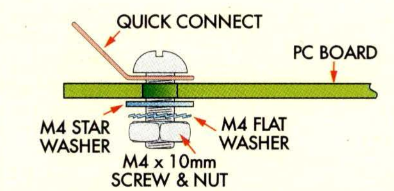


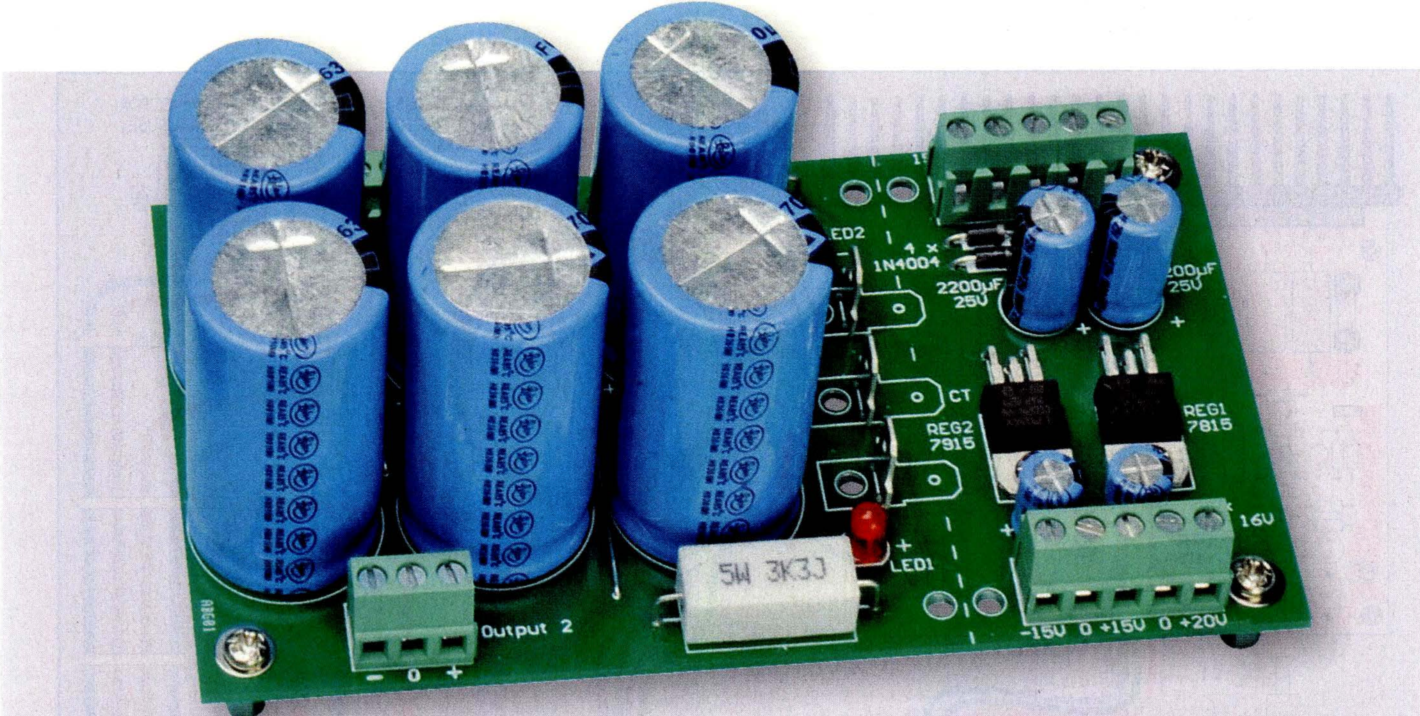
Fig.19: here's how the single-ended male Quick Connects are secured to the power supply PC board.

Chassis assembly

We plan to provide detailed instructions for building a complete Ultra-LD Mk.3 Stereo Amplifier in a future issue. In the meantime, here are the basic details for those who wish to go it alone or build a basic mono power amplifier.

The chassis layout is important to achieve the stated performance, so be sure to follow these instructions. In addition, safety is of the utmost importance, especially for mains wiring and chassis earthing.

Basically, the amplifier module(s) and the power supply (along with the transformer) must be housed in an earthed metal case. This must be large enough to provide sufficient room between the transformer and the amplifier modules to avoid hum cou-



The power supply board has ±57V output connectors on either side (CON1 & CON2) so that it can be easily connected to two separate power amplifiers. Note that this particular module has the alternative Quick Connect terminals from Altronics (ie, they are soldered to the PCB). The preamplifier supply section with the two 3-terminal regulators can be separated from the high-voltage supply section if necessary.

Power Supply Parts List

1 PCB, code 01109111, 141 x 80mm
4 3-way PCB-mount terminal blocks, 5.08mm pitch (Altronics P2035A or equivalent) (CON1-4)
2 2-way PCB-mount terminal blocks, 5.08mm pitch (Altronics P2034A) (CON5-6)
3 PCB-mount or chassis-mount spade connectors (Altronics H2094)
3 M4 x 10mm screws, nuts, flat washers and shakeproof washers (if using chassis-mount spade connectors)
4 M3 x 9mm tapped Nylon spacers
6 M3 x 6mm machine screws
2 M3 shakeproof washers and nuts
150mm 0.7mm diameter tinned copper wire

Semiconductors
1 7815 1A 15V positive linear regulator (REG1)
1 7915 1A 15V negative linear regulator (REG2)
4 1N4004 1A diodes (D1-D4)
1 5mm green LED (LED1)
1 5mm yellow LED (LED2)

Capacitors
6 4700µF 63V electrolytic
2 2200µF 25V electrolytic
2 220µF 16V electrolytic

Resistors
2 3.3kΩ 5W

Parts For Complete Stereo Power Amplifier
2 Ultra-LD Mk.3 amplifier modules
1 Ultra-LD Mk.3 power supply module
1 speaker protection module (to be described next month)
1 vented metal case, 2U/3U rack-mount or similar size (eg, Altronics H5047)
1 chassis-mount IEC mains input socket with fuseholder (use Altronics P8324 for recommended case)
1 M205 5A fuse
1 mains-rated power switch (eg, Altronics S4243A)
1 300VA transformer with two 40VAC 300VA windings and two 15VAC 7.5VA windings
1 35A 400V chassis-mount bridge rectifier
1 white insulated chassis-mount RCA socket
1 red insulated chassis-mount RCA socket
2 red and 2 black chassis-mount speaker terminals (or two double speaker terminals)
1 10kΩ dual-gang log potentiometer with suitable knob (optional, for volume control)
M3 and M4 screws, washers & nuts for mounting bridge rectifier, PCBs and heatsinks
Mains flex (approximately 2m)
Mains-rated heavy duty wire (approximately 2m)
Shielded wire for input signals (approximately 2m)
Speaker cable (about 0.5m)
Heatshrink tubing
Fully-insulated 6.3mm spade crimp connectors (about 20)

pling. It's also critical to use shielded cable for all the audio signal wiring, ie, between the input connectors and amplifier module(s).

You will need a 2U or 3U extra-deep rack-mount metal case (or a similar enclosure) to fit a complete stereo amplifier. It will need to be quite strong to support the weight of the heatsinks and the transformer. Good ventilation is also important and ideally there should be vents immediately

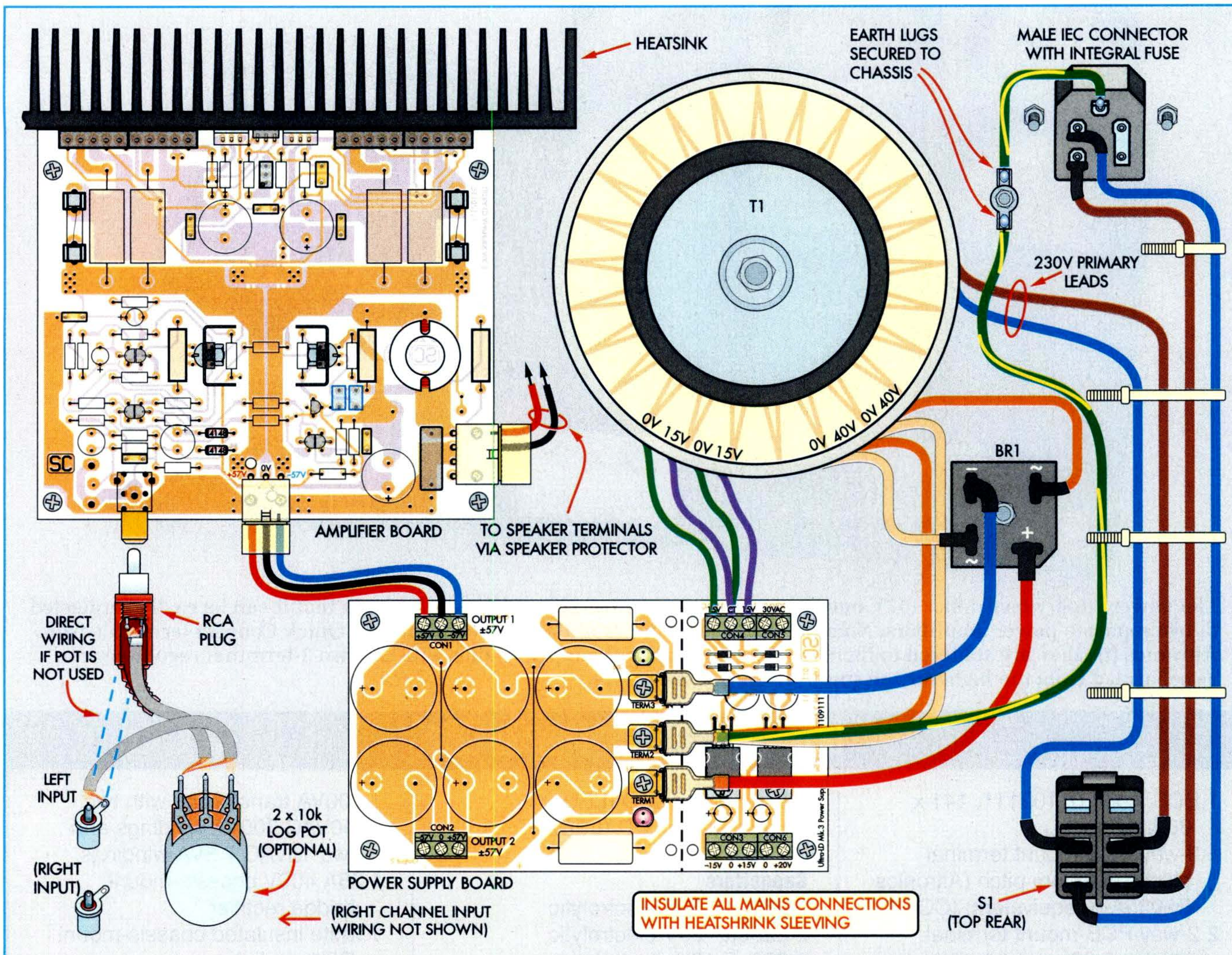


Fig.20: here's how to wire the completed power amplifier and power supply boards into a metal case. Make sure that all exposed terminals on the IEC connector and mains switch are fully insulated – see text.

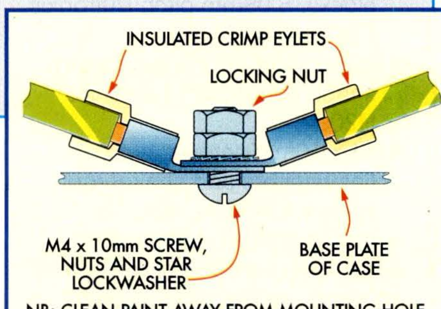


Fig.21: the chassis earth point is installed as shown here. Two nuts are used to permanently lock the assembly in place. Make sure that it forms a good electrical contact with the chassis.

surrounding the heatsinks.

The power transformer and IEC connector should be mounted towards the back (either in the lefthand or righthand rear corner), while the amplifier modules can be positioned on either side of the case, near the front. The power supply board can then fit between the amplifier modules, with its ±57V outputs lined up with the supply connector(s) on the module(s).

It's also vital to include a loudspeaker protector module (not shown in Fig.20) – see panel overleaf.

The speaker protection module can be mounted towards the centre-rear of the chassis, while the RCA input connectors can be mounted in the opposite corner to the mains input.

The volume control is optional but most constructors will want one, unless they are using an external preamplifier. No input switching is shown on Fig.20 but this will be a feature (with remote control) of the full stereo amplifier to be featured later.

Checking the wiring

Fig.20 shows the wiring connections. **Make sure that the chassis is securely earthed via the mains and be sure to insulate all exposed mains terminals with heatshrink sleeving.**

Fig.21 shows how the earth lugs are secured to the chassis using an M4 x 10mm screw, a lock-washer and two nuts. Make sure that the earth leads are securely crimped or soldered to these lugs before bolting them to the chassis.

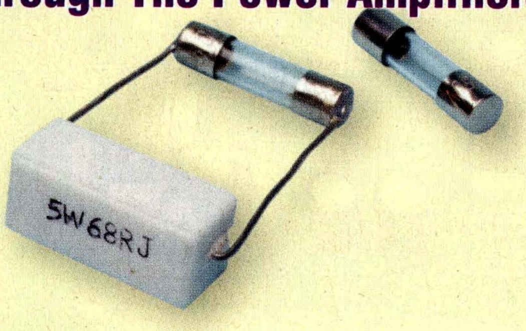
Once you've done this, use a multimeter to confirm the earth connection. You can do that by checking for continuity between the earth terminal of the IEC socket and the chassis.

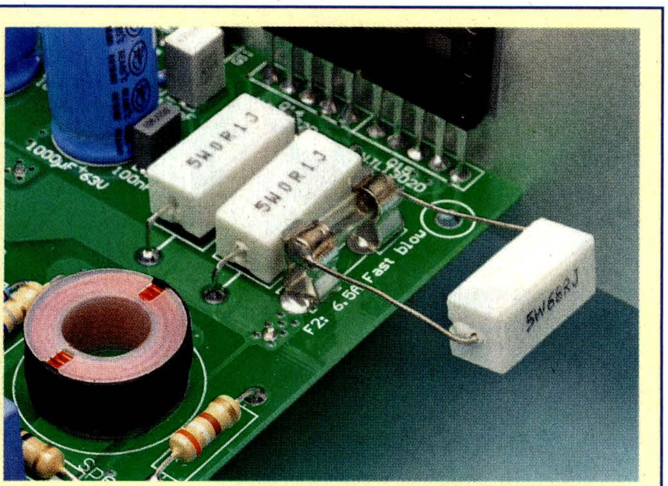
Testing the power supply

Once the assembly is complete, check your wiring very carefully. In particular, make sure that BR1's positive and negative terminals connect to the correct terminals on the power supply board.

It's now time to check that the power supply is functioning correctly but first

Adjusting The Quiescent Current Through The Power Amplifiers





The quiescent current flowing in the output stage of each power amplifier is initially adjusted by installing 68Ω 5W resistors in place of the fuses. The voltage across one resistor is then monitored and trimpot VR1 adjusted for a reading of 9.5V – equivalent to a quiescent current of 70mA.

The easiest way to connect the resistors is to "blow" the fuse wires in a couple of spare M205 fuses, then drill holes in the end caps and solder the resistors in place as shown. The original fuses can then be removed and the "modified" fuses clipped into place – see photo.

a warning: **the metal strap that runs from the Active terminal to one end of the fuse has 230V AC on it. You should insulate this terminal using neutral-cure silicone sealant or you can cover the IEC socket with a rubber boot, eg, Jaycar Cat. PM-4016.**

To check the power supply, first make sure that the supply wiring is disconnected from the amplifier. That done, apply power and check the various DC outputs. You should be able to measure close to ±57V on CON1 & CON2, +20V on CON6, ±15V on CON3 and 30VAC on CON5.

If you don't get the correct voltages, switch off immediately and check for wiring and component errors.

Testing the power amplifier

Each power amplifier must be tested with 68Ω 5W "safety" resistor in series with its fuse clips. These are necessary to limit the current through the output stage to about 840mA if there is a fault in the module that turns the output transistors on hard. This protects the output transistors from damage but note that the 68Ω resistors will quickly burn out under such circumstances (since they would be dissipating over 40W).

As well as protecting the output stage, the 68Ω resistors allow you to initially set the quiescent current. That's done by monitoring the voltage across one resistor and adjusting trimpot VR1 to give a reading of 9.5V (equivalent to a quiescent current of about 70mA).

The easiest way to connect the 68Ω safety resistors is to solder them across two blown M205 fuses. If you don't have any blown fuses, you can purposefully blow some by connecting them directly across a power supply. It's then just a matter of drilling holes in the end caps, bending the resistor leads to go through them and soldering them in place.

These two modified "fuses" are then clipped into the fuse clips on either side of the module – see photo.

Each amplifier module is now ready for testing.

STEP 1: check that the safety resistors are installed and that their leads can't short to any adjacent parts **(note: do NOT connect the loudspeaker to the amplifier during this procedure).**

DANGER: HIGH VOLTAGE

High DC and high AC voltages are present in this circuit. The power supply uses a total of **80V AC and the amplifier power supply rails are a total of 114V DC.** Do not touch any part of the amplifier circuitry when power is applied otherwise you could get a severe electric shock.

The two LEDs on the power supply board indicate when power is present. If they are alight, the power supply and amplifier boards are potentially dangerous.

STEP 2: connect a DMM set to volts across one of the safety resistors (alligator clip leads are extremely handy in this situation).

STEP 3: turn trimpot VR1 fully anticlockwise. This can take as many as 25 turns but it will continue to turn even so. Many (but not all) multi-turn trimpots click when they are at the end-stop. If in doubt, check the resistance across it – it should be about 1kΩ.

STEP 4: check that the power supply is off and that the filter capacitors are discharged (LEDs off!), then connect the ±57V supply to the module. Check that the supply polarity is correct, otherwise the amplifier will be damaged when power is applied.

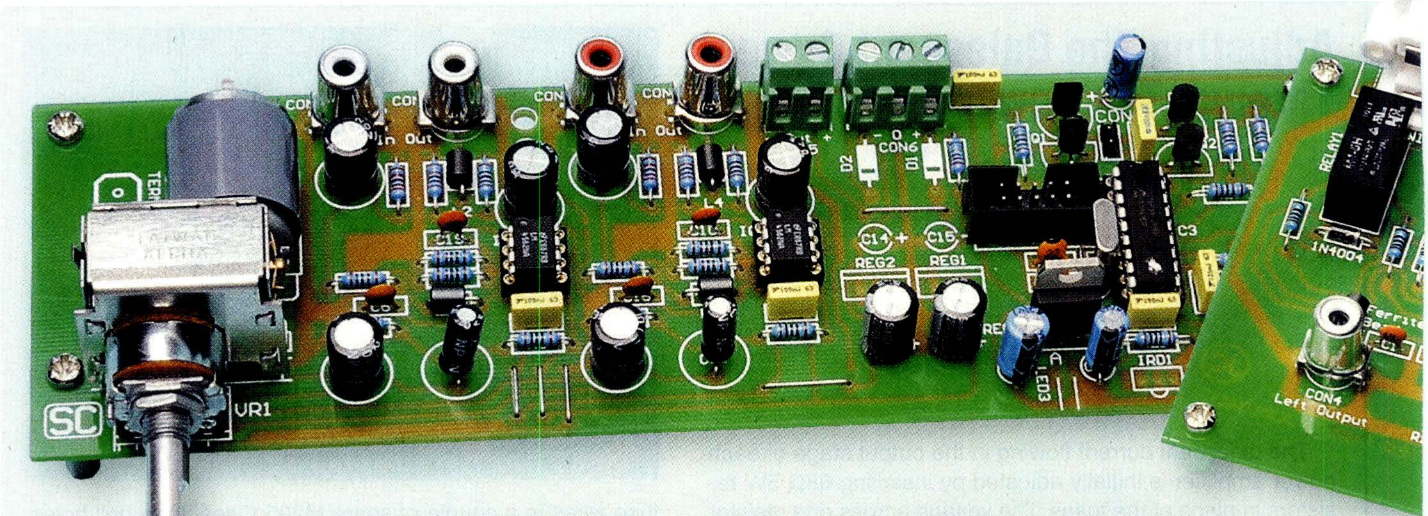
STEP 5: apply power and check the voltage across the 68Ω resistor. It should be less than 1V (it may jump around a bit). If the reading is over 10V, switch off immediately and check for faults.

STEP 6: using an insulated adjustment tool or a small flat-bladed screwdriver, slowly adjust the trimpot clockwise. Be careful not to short any adjacent components.

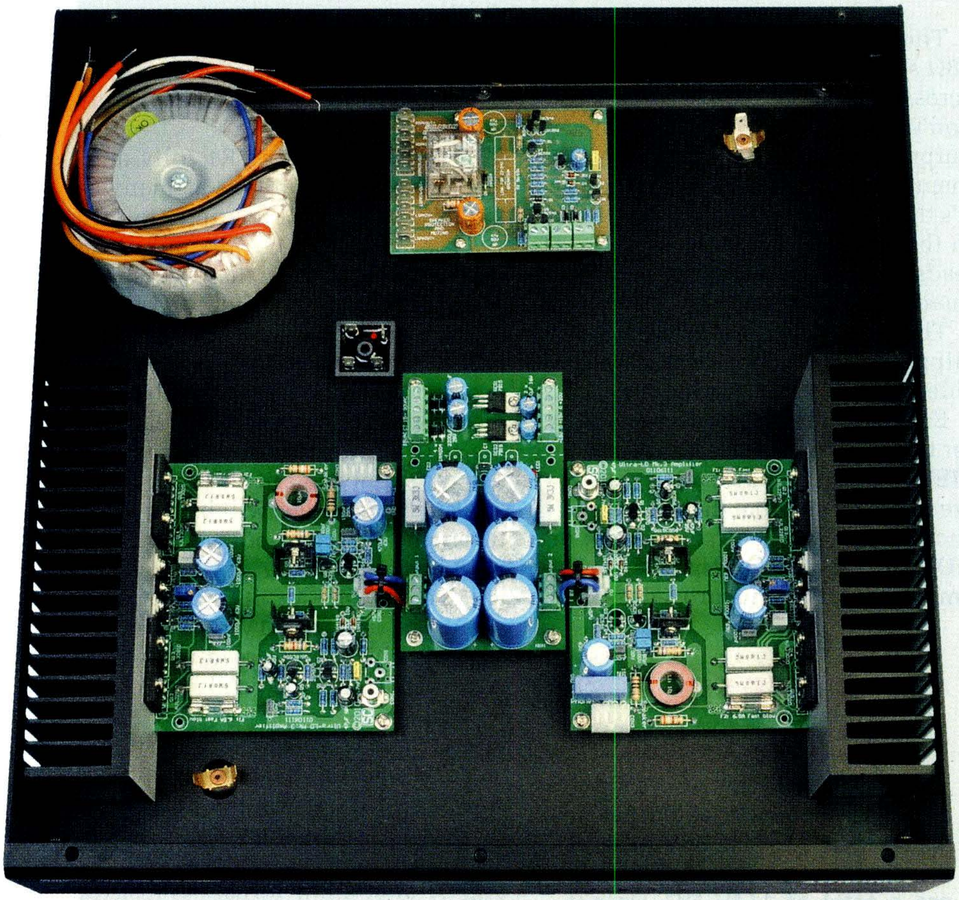
STEP 7: after a few turns, the resistor voltage should stabilise and start to rise. Continue until it reads around 9.5V. It may drift a little but should be quite steady.

STEP 8: check the voltage across the amplifier's output terminals (ie, across the speaker terminals). It should be less than ±50mV.

STEP 9: switch off, wait for the capacitors to fully discharge (LEDS off) and



WHAT'S COMING: in future issues, we intend to describe a low-noise stereo preamplifier board (above) with remote volume control plus a 3-input selector board (right) which is controlled by the same remote. The preamp is a slightly modified version of the unit described in August 2007 for the 20W Class-A Stereo Amplifier while the input board is completely new. The latter uses relay switching and features internal RCA output sockets which connect to matching input sockets on the preamp.



The power supply can sit in the chassis with its ±57V output connectors aligned with the supply connectors on two power amplifier modules.

replace the safety resistors with 6.5A fuses.

STEP 10: connect a DMM set to volts across one of the 0.1Ω 5W emitter resistors.

STEP 11: reapply power and check that the DMM reads close to 7mV. If necessary readjust trimpot VR1 to bring the voltage close to this figure.

It's a good idea to recheck this resistor voltage after the amplifier has been idling for an hour or so with the lid on. If the reading is more than 15mV, readjust VR1 anti-clockwise to bring it back below this figure. The stability is such that it should stay below this figure but it's a good idea to check.

That completes the quiescent current adjustments. **Note, however, that if you wish to repeat the above procedure (ie, with the 68Ω resistors in place), you will first have to reset VR1 to minimum (ie, fully anti-clockwise). If you don't do this, the amplifier may latch up when power is reapplied and burn out the safety resistors.**

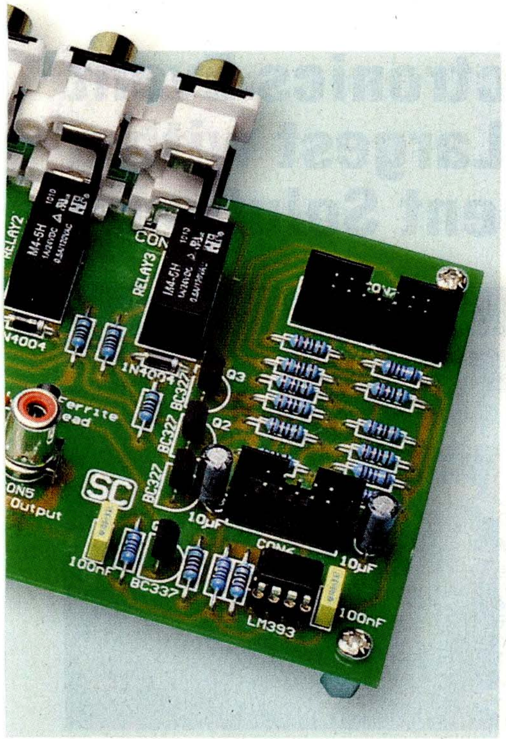
Troubleshooting

If there's a fault in the module, a likely symptom is either excessive voltage across the safety resistors or the amplifier output voltage is pegged near one of the ±57V supply rails.

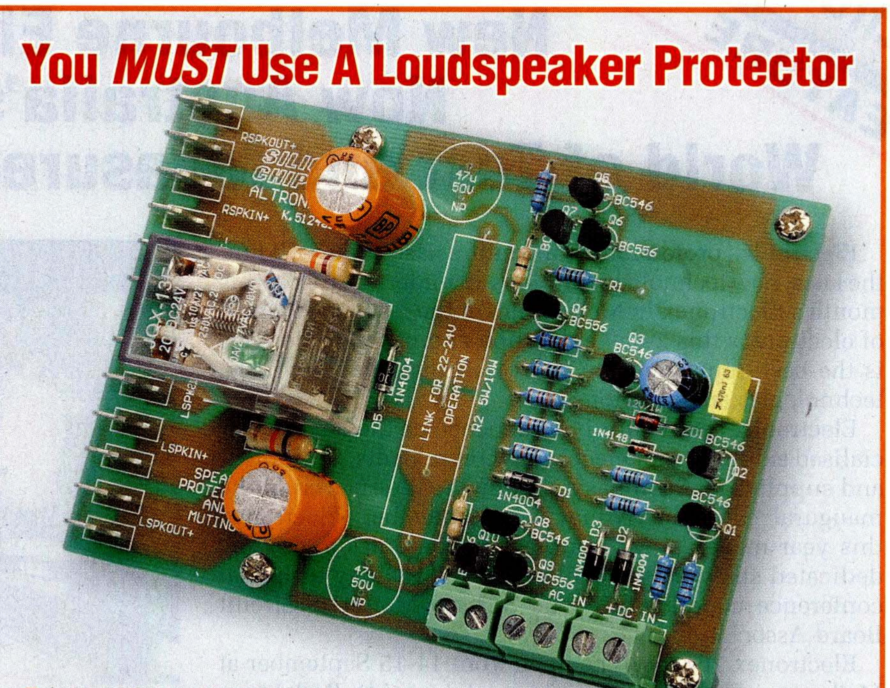
If this happens, switch off and wait for the power supply capacitors to discharge. That done, check that all the transistors are properly isolated from the heatsink.

If this checks out, apply power to the amplifier without the fuses or safety resistors in place – ie, so that the output stage (Q10-Q15) is left unpowered. Now check the voltage between the bases of transistors Q10 & Q11. This should be close to 2.2V.

If this voltage is too high and you can't reduce it with the trimpot, there could be a fault in the V_{BE} multiplier (Q16 and associated components) or an open circuit between it and the



You *MUST* Use A Loudspeaker Protector



AS STATED in the main body of the article, it's essential to use a loudspeaker protector with the Ultra-LD Mk.3 amplifier module (and with any other high-power audio amplifier module for that matter).

That's because if a fault occurs in the amplifier (eg, if one of the transistors fails), this could apply one of the full 57V supply rails to the loudspeaker's voice coil. As a result, the voice coil would quickly become red hot and burn out, irreparably damaging the speaker. This may also cause a fire!

This slightly-modified version of the "Universal Speaker Protector & Muting Module" described in the July 2007 issue of SILICON CHIP will prevent this from happening. This device not only quickly disconnects the loudspeaker(s) in the event of a DC output fault but also provides muting at switch-on and switch-off to prevent audible thumps. It also includes an input for an optional temperature sensor to disconnect the loudspeaker(s) if the output stage heatsink rises above a preset temperature.

The full details of this modified loudspeaker protector will be published next month.

diode leads of Q12-Q15. This could be due to an open-circuit track on the PCB or more likely, missed solder connections on the output transistor leads.

If the voltage between the bases of Q10 & Q11 is correct (ie, 2.2V), check the other voltages indicated on the circuit diagram. Note that the supply rails can vary by a few volts depending on your exact mains voltage, so some of the voltages can vary somewhat.

In addition, check the base-emitter voltage of every transistor in the amplifier. In each case, you should get a reading of 0.6-0.7V if the transistor is working correctly. If not, then either the transistor is faulty or the wrong type has been used in that location.

Making repairs

If you need to remove a faulty component from a double-sided PCB, the best approach is to first cut the body of faulty component away from its leads. It's then just a matter of grabbing them one at a time with pliers, heating the solder joint and pulling gently until the lead comes out.

Once the leads have been removed, use a solder sucker or vacuum desoldering tool to clear the holes. **SC**

Electronex electronics design & assembly expo FEATURE

New Melbourne Electronics Event Now Australia's Largest with a World of Test and Measurement Solutions!

Electronics professionals and enthusiasts alike will find the latest new technology solutions all under one roof at this month's Electronex in Melbourne. In the fast paced world of electronics this 2-day exhibition and major conference is the best opportunity to source all the latest products, technologies and solutions.

Electronex is now firmly established as the largest specialised exhibition for electronics components, equipment and supplies in Australasia. Following the success of the inaugural event in Sydney last September, Electronex this year moves to Melbourne and combines a growing dedicated show of 90+ exhibitors with a 2-day technical conference conducted by the Surface Mount & Circuit Board Association.

Electronex 2011 will be open from 14-15 September at Melbourne Park Function Centre (alongside Rod Laver Tennis Arena) which is conveniently located less than 1km from the city centre, with easy access and ample parking for visitors.

Electronex provides the most comprehensive and diverse showcase you will see in Australia of specialist organisations providing the latest products and services for electronic product design, development, assembly, manufacture,

test, measurement, repair, systems and component supply.

And with practically every major Test & Measurement Equipment supplier launching new equipment ranges at the event you will see every conceivable equipment option for your test, measurement, servicing and maintenance requirements.

"Last year's show established this event as the largest electronics forum to be staged in many years in Australia for the Australasian region," said Noel Gray (Managing Director, AEE Pty Ltd). "This year's Melbourne event; which has increased in size and is expected to attract even larger attendance re-affirms its continued pre-eminence and the growing support and enthusiasm for a specialised electronics industry platform showcasing local Australian & NZ based suppliers and distributors of the latest electronics technology for our market".

Attendance to the Electronex exhibition is free to all business attendees & trade visitors.

For show information and business registration details please visit the show website **www.electronex.com.au**

Contact: Noel Gray/ Anthony Doran
Australasian Exhibitions & Events Pty Ltd
Ph: (03) 9676 2133 Fax: (03) 9676 2533
Email: **ngray@auexhibitions.com.au**

New Generation Circuit Board Plotters

LPKF introduces three new machines with different feature sets at Electronex.

The entry level model, the ProtoMat S43, will handle drilling, depaneling and most structuring jobs. The system is also suitable for engraving housing front panels.

The S63 adds convenience. The all-rounder in Rapid PCB Prototyping, it features a paste dispenser, which applies soldering paste with absolute precision. The unit also includes a fiducial camera and a 15-position automatic tool change and automatic milling width adjustment. It is ideal for accurately machining double-sided circuit boards.

The top-of-the-line ProtoMat S103 features a vacuum table and pneumatic milling depth limiter. This extends the machining capabilities to delicate materials requiring ultimate precision as is typical in RF or microwave applications.

Aside from the new S-Series ProtoMats, LPKF has introduced a low priced entry-level model, the ProtoMat E33. Embedded Logic Solutions are on stand C27 at Electronex.

Electronex FEATURE

Rohde & Schwarz ZNB and ZNC Vector Network Analysers

On display at Electronex will be two new Vector Network Analysers from Rohde & Schwarz.

The R&S ZNB is a new and superior mid-range vector network analyser. It is a general-purpose instrument that is ideal for use in component production lines for mobile radio or wireless applications as well as for production repair stations.

It is also tailored to general network analysis applications in development, research, education and service.

The R&S ZNB is available as a two-port and four-port version for frequency ranges up to 4.5 GHz and 8.5 GHz.

The state-of-the art design has a higher measurement speed, a wider dynamic range and better RF specification (including raw data) than anything currently on the market.

It features a large display (16:9 aspect ratio) with touchscreen and comprehensive functionality, including soft tools and softkeys for operating convenience. Its high measurement accuracy, low trace noise and long-term stability make it ideal for challenging applications.

The R&S ZNC is a low-cost version of the R&S ZNB. They look the same, but the R&S ZNC is only available as a two-port version for frequency ranges up to 3 GHz.

You'll find Rohde & Schwarz on stand C05 at Electronex 2011.

Electronex electronics design & assembly expo FEATURE

New Electrolube Silicone Resin Range Previewed Ahead of Show

Electrolube will launch a number of innovative new silicone resins at the Electronex Exhibition, Melbourne (stand D90).

The '2000' silicone resin range includes SC2001, a general potting and encapsulating compound; SC2001FD, a fast cure compound and SC2003, a thixotropic compound.

The new range, which will be available to view at Electronex, adds even more choice to Electrolube's range. The new silicone resins all have high continuous operating temperatures, making them the perfect barrier against extreme conditions.

SC2001 is a two-part compound with exceptional flexibility, flame retardancy and high temperature properties (up to 200°C), excellent for both chemical and water resistance. As a general potting and encapsulating compound, it is tipped to become one of the best all-round silicone resins available in the Electrolube range.

Also newly developed is SC2001FD, the fast cure addition to the new range. The two-part compound, like SC2001, has exceptional flame retardency, flexibility, low shrinkage and high temperature but it also has a fast cure nature, particularly suitable for use in automated mixing and dispensing equipment.

The third new product, SC2003, includes high thixotropy, suitable for use in applications where the operating temperature is up to 200°C. With a 1:1 ratio, flame retardancy, excellent flexibility and both chemical and water resistance, it offers yet another dimension to Electrolube's product range.

With varying hardness, viscosity and gel time, as well as differing electrical and thermal properties, Electrolube's impressive range of resins will form part of the products to be exhibited at Electronex this year.

SOLARKING Monocrystalline 12V Solar Panels

Monocrystalline solar panels are designed for long life (up to 20 years) and high efficiency output. These units may be ganged into arrays for applications where high power output is required eg for large battery banks. An excellent solution for remote or mobile power applications, electric fence battery banks, inverter systems, RV's, caravans, boats etc.
All aluminium frames and tempered glass panels allow installation in the most demanding environments.
To prevent moisture ingress, the solar cell modules are laminated between sheets of high transmissivity 3mm tempered glass, tedlarpolyester-tedlar (TPT) material and sheets of ethylene vinyl acetate (EVA).

Stock#:	Max Power	Rated Voltage	Short Cct Curr.	Open Cct.	Dimensions LxWxH	Price
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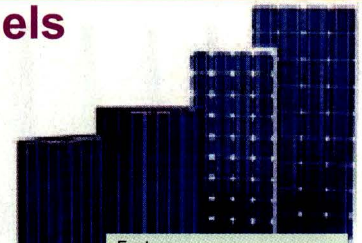
#36995	**20W**	12.0V	**1.17A**	21.6V	645 x 295 x 25	**$59.50**
#36996	**40W**	12.0V	**2.28A**	21V	645 x 545 x 23	**$134.50**
#36997	**80W**	12.0V	**4.55A**	21.8V	1210 x 540 x 35	**$220.50**
#37873	**120W**	12.0V	**6.82A**	21.8V	1500 x 660 x 35	**$405.50**



Features:
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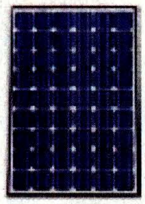
*20 Year Limited Warranty
*Monocrytalline Silicone
*3.2mm Tampered Glass

24V 180W Monocrystalline Solar Panel



Max system voltage (V): 1000V
Temperature coefficients of Isc (%): 0.06% / °C
Temperature coefficients of Voc (%): -0.397% / °C
Temperature coefficients of Pm (%): -0.549% / °C
Nominal operating cell temperature: 45.3°C ±2°C
Temperature range: -40° to +90°C
Surface max load capacity: 200kgs/m2
Allowable hail load: 25mm @ 80km/h
Efficiency for module: 14.1%
Efficiency for cell: 16.2%
Connections: 4.0mm2 900mm length, MC-4 plugs (1 plug, 1 socket)
Output warranty: 90% output for first 10 years,
80% output for following 15 years

Specifications
Max power (Wp): 180W
Max power voltage (V): 34.00V
Max power current (A): 5.3A
Open circuit voltage (V): 43.00V
Short circuit current (A): 5.58A
Bypass Diodes: 3
Size of module: 1580 x 800 x 35mm
Size of glass: 1574 x 793 x 3.2mm
Size of solar cells: Mono 125 x 125mm
Number of cells: 72

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Specifications:
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Signal level: -65dBm ~ 25dbm
Video format: PAL/ NTSC
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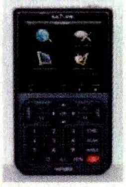

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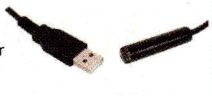
*Fully DVB Compliant

$315.00

Specifications: **#38396**
Freq range: 950mHz-2150mHz
Signal level: 65dbm~25dbm
Symbol rate: 2mbps~45mbps
Video format: PAL/NTSC/SECAM
Software Upgradeable via USB
Size: 158x95x45
Manuf.: SATLINK WS-6902

Includes:
* 240v Charger Australian plug
* 12volt Cigarette Lighter Cable
* USB Cable & Strap

USB Mini Inspection Camera (520mm Neck)



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When Equip. connected to the master socket is turned off/on the power to the 4 slave sockets is switched to the same status.
* Save up the $70.00 per year.
* JACKSON PT9778
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LED 10W 12VDC Cool White Flood Light

#39322

Device: GT-T03W102
Description: LED Flood Light
Input Voltage: 12VDC
Power: 10W
TC(nm): 6000-7000K
Lumen: 600-700LM
Size: 114(W) x 86(H) x 83(D)mm
Manufacturer: Shenzhen Getian

$65.40

LED 20W 12VDC Cool White Flood Light

#39452

Device: GT-T04W202
Description: LED Flood Light
Input Voltage: 12VDC
Power: 20W
TC(nm): 6000-7000K
Lumen: 1200-1400LM
Size: 225(W) x 186++(H) x 135(D)mm
Manufacturer: Shenzhen Getian

$143.50

3 x 1W 200-250LM/W 12VAC/DC Led Lamp

Device:GT-S03W0310316
Description:Led Spotlight
Input Voltage:12VAC/DC
Power:3 x 1W
TC(nm):6000-7000K
Luminous Efficiency:200-250LM/W
Manufacturer:Shenzhen Getian

$19.50 **#39361**

12VDC Water Pump (25mm Outlet Dia.)

Device:BL-2512S
Volume delivery: 70L per minute
Delivery head: 4m
Current: 5.4A
Life span: least 500Hrs
Motor power: 50W / 5800rpm
Weight: 1.3kg Inc. 1 Elbow
Marine Pet

#37855 **$29.75**

LED 10W 12VDC RGB Flood Light

$85.90

Device:GT-T03RGB102
Description:AUTO Colour Sequencing RGB LED Flood Light
Input Voltage:12VAC/DC
Power:10W
TC(nm):2000-5000k,5000-1000(
Luminous Efficiency:90LM/W
Manufacturer:Shenzhen Getian

#39327

LED 50W 24VDC Cool White Flood Light

#39460

Device:GT-T02W502
Description:LED Flood Light
Input Voltage:24VDC
Power:50W
TC(nm):6000-7000K
Lumen:3000-3500LM
Size: 285(W) x 235(H) x 150(D)mm
Manufacturer:Shenzhen Getian

$193.50

LED MR16 1W Cool White 12VAC/DC Lamp

Device: GT-S01W0120116
Description: MR16 Led Spotlight
Input Voltage: 12VAC/DC
Power: 1.1W
TC(nm): 6000-7000K
Luminous Efficiency: 90-100LM/W
Manufacturer: Shenzhen Getian

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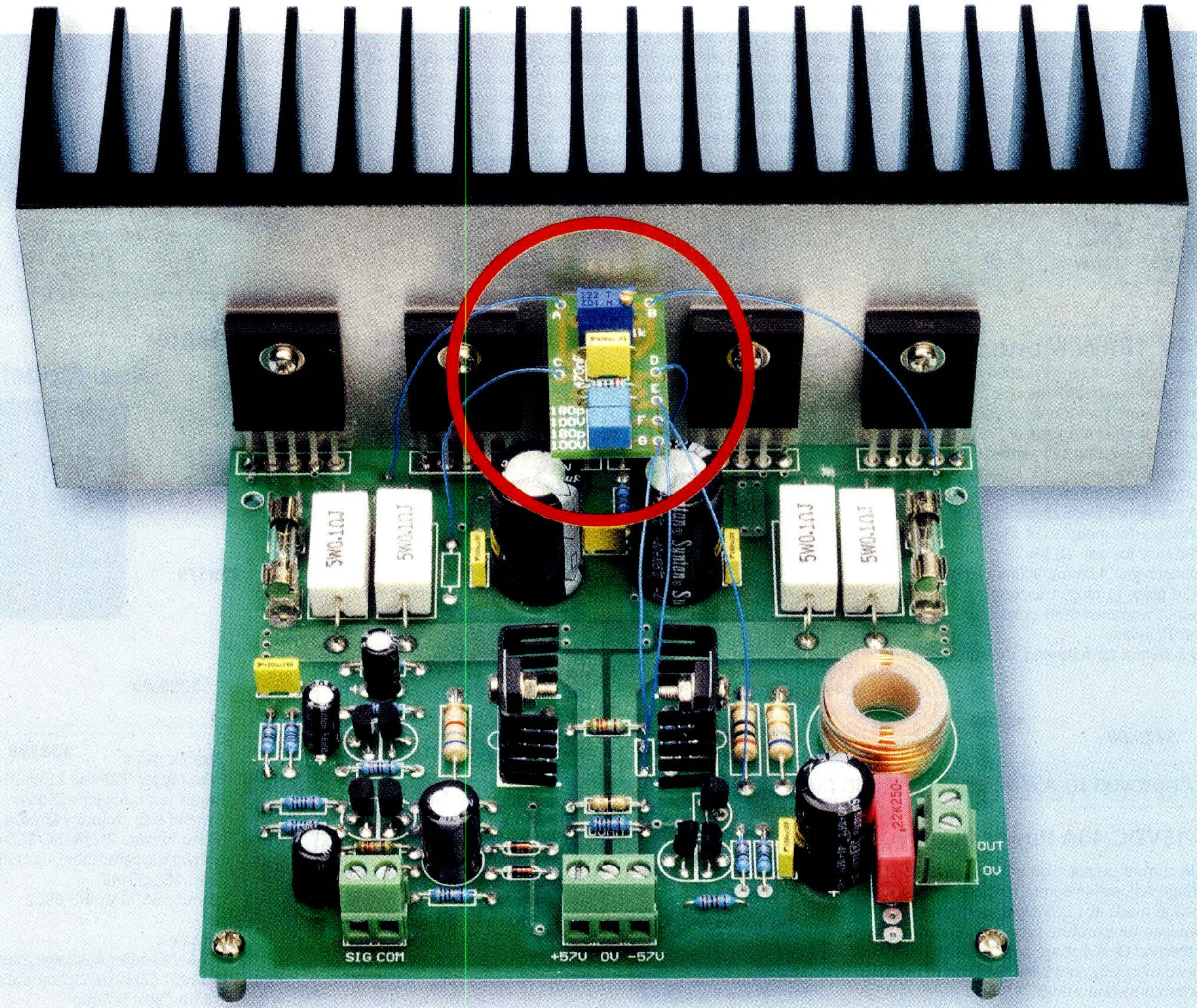


Upgrading an Ultra-LD Mk.2 amplifier to Mk.3 performance

By NICHOLAS VINEN

This teensy PCB lets you add the vital modifications to an Ultra-LD Mk.2 amplifier to bring it up to Mk.3 performance. We are doing this so that all those people who built the Ultra-LD Mk.2 from the August-September 2008 issues will not be too annoyed with us for superseding it with the Mk.3 version. After all, we want to keep our readers happy and content!

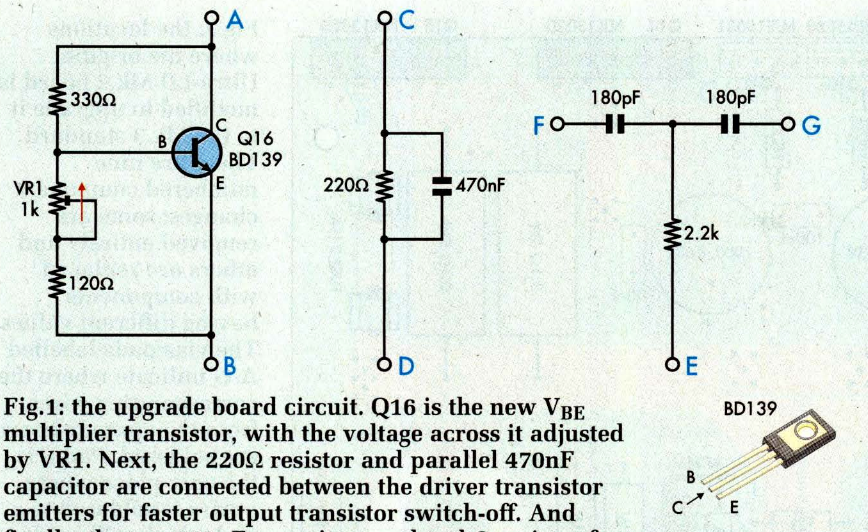


Fig.1: the upgrade board circuit. Q16 is the new V_{BE} multiplier transistor, with the voltage across it adjusted by VR1. Next, the 220Ω resistor and parallel 470nF capacitor are connected between the driver transistor emitters for faster output transistor switch-off. And finally, the two 180pF capacitors and 2.2kΩ resistor form a double-pole filter across the transimpedance stage transistor on the main board, providing increased open loop gain in the audio band while retaining stability.

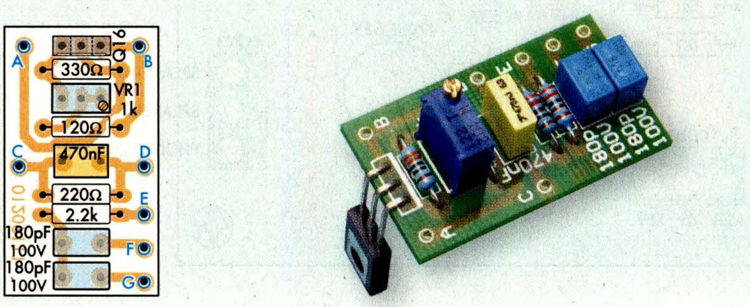


Fig.2: the parts layout on the upgrade PCB. Transistor Q16 is mounted on the component side, as far above the PCB as possible. Its leads are then bent around the board's edge so that it "hangs" upside-down from it, ultimately supporting the PCB on the heatsink – see photo.

THIS TINY upgrade board carries the new components, ie, the V_{BE} multiplier transistor (Q16), the new driver transistor emitter arrangement and the 2-pole compensation filter. A few other changes are made by replacing components directly on the board. The upgrade board is mounted on the heatsink via the V_{BE} multiplier transistor and wired to pads on the main amplifier board via flying leads.

In summary, the changes to upgrade an Ultra-LD Mk.2 to Mk.3 standard are:

(1) Two of the ThermalTrak diodes in the bias voltage generator are replaced with an adjustable V_{BE} multiplier, allowing quiescent current adjustment and providing better thermal stability. The constant current source resistor is also changed to 68Ω for correct biasing.

(2) The two driver emitter resistors are replaced by a single resistor, bypassed by a 470nF capacitor. This speeds up output transistor turn-off and so reduces high-frequency distortion.

(3) The 100pF Miller capacitor, connected between the collector of Q9 and the base of Q8, is replaced with two 180pF capacitors and a 2.2kΩ resistor. This replaces the single-pole compensation scheme with a 2-pole filter for more open loop gain at audio frequencies.

(4) The feedback capacitor goes from 220μF to 1000μF, which reduces distortion and flattens the response at very low audio frequencies. It also slightly improves the signal-to-noise ratio.

(5) The 820pF input filter capacitor is increased to 4.7nF, for more effective RF filtering.

(6) The output filter inductor and capacitor values are increased, improving magnetic field cancellation and thus lowering high-frequency distortion further.

Of these changes, the first three are incorporated on the upgrade board while the remainder involve component replacements on the main PCB.

Table 1

Wire/Pad	Length
A	70mm
B	80mm
C	60mm
D	50mm
E	85mm
F/G	75mm

Construction

The first step to upgrade the amplifier module is to assemble the upgrade board. This is built on a PCB coded 01209111 and measuring 20.5 x 36.5mm.

Begin by fitting the four resistors. Check each one with a DMM set to Ohms mode before installing it. Follow with the two 180pF polypropylene capacitors, then fit the 470nF MKT capacitor and trimpot VR1. The latter should go in with its screw terminal to the right side of the board – see Fig.2.

That leaves Q16, the BD139 transistor. It should be soldered to the top of the board, with its metal tab facing away from the nearest edge and with its leads just protruding through the bottom of the board by a millimetre or two. Solder one pin, then ensure it is in straight before soldering the other two. With all three leads soldered, bend it around the edge of the PCB until its leads form a "J" shape, as shown in the photo.

Now solder lengths of wire to the pads marked "A" through "G". The length required for each wire is shown in Table 1.

Modifying the module

If the module has already been installed in a chassis, remove it. Undo the six screws holding the transistors to the heatsink and separate the PCB. The silicone rubber washers can sometimes "stick" so you may need to gently pry the transistors off the heatsink. Remove any silicone rubber washers that are stuck on the heatsink.

Now mark out and drill the extra mounting hole shown in Fig.4 (for the V_{BE} multiplier transistor). It goes in the same place whether you are tapping the heatsink or drilling right through; in either case it is between the fins.

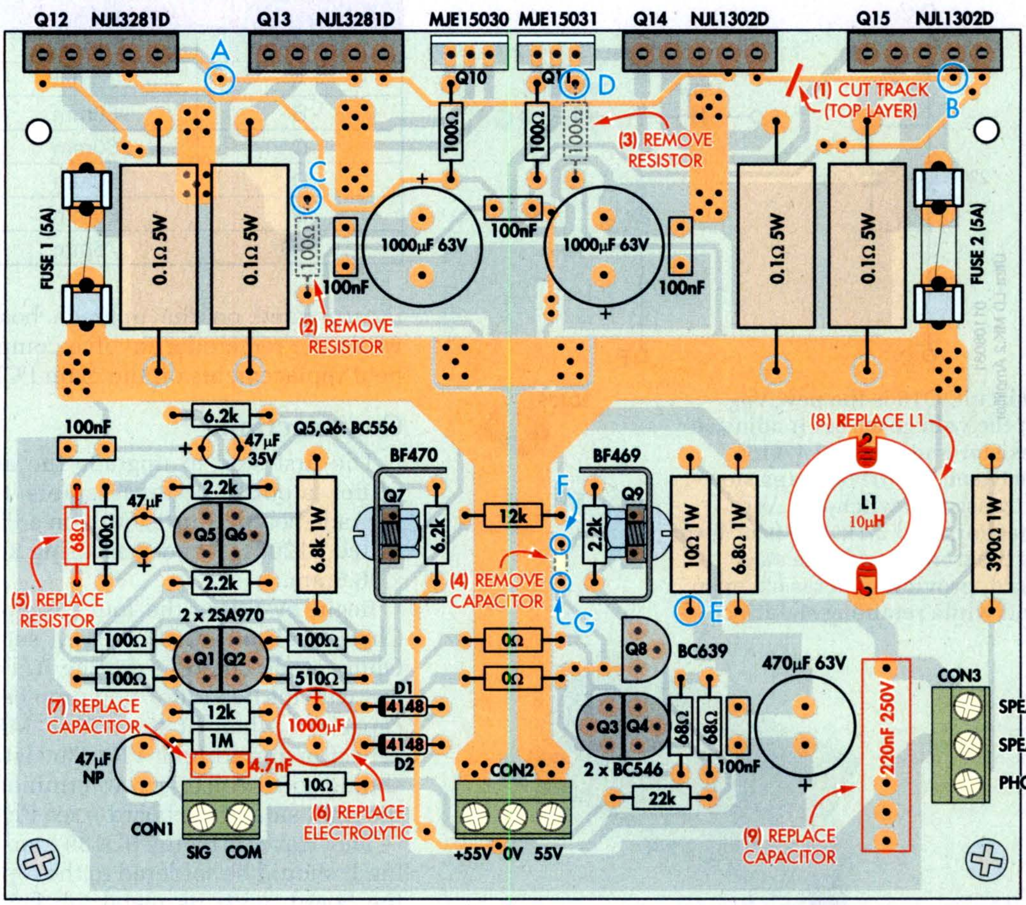


Fig.3: the locations where the original Ultra-LD Mk.2 board is modified to upgrade it to the Mk.3 standard. There are nine numbered component changes; some are removed entirely and others are replaced with components having different values. The vias/pads labelled A-G indicate where the corresponding wires from the upgrade board are soldered. Pad E is the only place where a wire is soldered to a pad which still holds a component lead.

As we stated in the Ultra-LD Mk.3 construction article last month, you must use a lubricant such as Kerosene or 3-in-1 oil when drilling or tapping aluminium. Regularly clear the swarf from the hole, especially during the tapping process.

It's easiest to start with a small pilot drill and slowly enlarge the hole to size. You can either drill the hole to 2.5mm and tap it for an M3 thread, or just drill a 3mm hole right through and use a longer machine screw and a nut between the heatsink fins.

When finished, de-burr it using a large drill bit and check that the surface of the heatsink is perfectly smooth. Then wash the oil residue off with some water and detergent and leave the heatsink to dry.

Removing parts

While the heatsink is drying you can make the necessary changes on the main amplifier PCB. This involves removing and in some cases replacing components.

This can be a little tricky on a double-sided PCB with plated through holes. To remove a resistor, cut one of its leads close to its body, then grasp the resistor with pliers and gently pull on it while heating the pad on the underside of the board. It should come out easily after a few seconds; if not, let the board cool down and try again. Use the same procedure to remove the remaining lead.

For components where you can't get at the leads, such as the inductor and the capacitors, the easiest method is to "rock" the component out. Heat one of its leads and gently pull it up on that side. The component will bend over slightly as the lead is withdrawn by a millimetre or two. Then heat and pull up the other side, bending the component over in the other direction. Repeat a few times and it will lift free of the board.

Once the component has been removed, the holes must be cleared of solder before it can be replaced. Use a solder sucker; heat the pad for a few

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	2.2kΩ	red red red brown	red red black brown brown
❑	1	330Ω	orange orange brown brown	orange orange black black brown
❑	1	220Ω	red red brown brown	red red black black brown
❑	1	120Ω	brown red brown brown	brown red black black brown
❑	1	68Ω	blue grey black brown	blue grey black gold brown

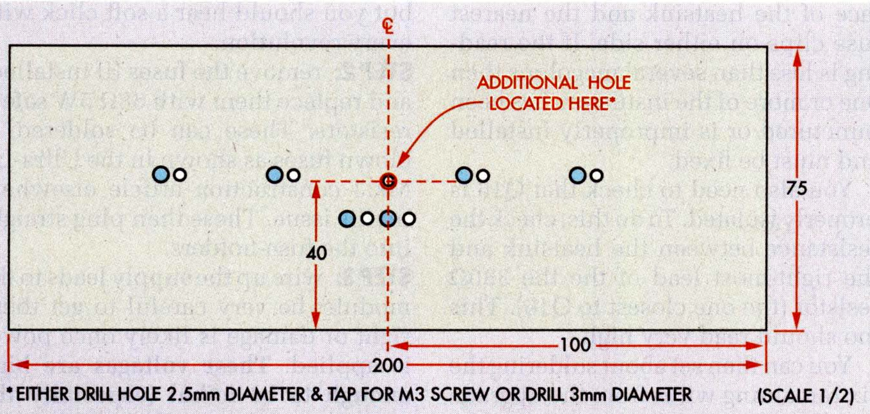


Fig.4: this half-size drilling template shows where the additional hole is drilled. It is in the same place regardless of whether you are going to tap it or not. If you are, drill it to 2.5mm and then use an M3 tap (it's easiest to drill right through the heatsink, then you don't need to use a finishing tap). Otherwise drill it to 3mm and use a longer (15mm) machine screw and nut to secure the V_{BE} multiplier transistor.

seconds before using it to ensure all the solder has melted. Solder suckers work best when the tip is right up against the hole to maximise suction.

If removing the solder from the upper pad doesn't clear the hole, apply the same technique to the opposite pad. If the hole is still blocked (even partially so), add some fresh solder to the pad (this also adds flux and helps the solder flow) and then try again.

Making the changes

Here are the changes you need to make. Be careful not to touch any plastic components (eg, capacitors) with the soldering iron while doing so. They are shown on the overlay diagram of Fig.3:

STEP 1: cut the top layer track connecting DQ14 and DQ15 using a sharp hobby knife. It's best to cut the track in two locations and lift out or obliterate the section between the cuts. Check that the vias at either end are not connected using a DMM on continuity mode.

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
470nF	0.47µF	470n	474
220nF	0.22µF	220n	224
4.7nF	.0047µF	4n7	472
180pF	NA	180p	181

STEP 2: remove the 100Ω resistor directly below Q13.

STEP 3: remove the 100Ω resistor connected to pin 3 of Q11.

STEP 4: remove the 100pF 100V capacitor near Q9.

STEP 5: if the current resistor value is not 68Ω, replace it with a 68Ω resistor.

STEP 6: remove the 220µF 16V capacitor and replace it with a 1000µF 16V capacitor (you may need to bend the leads of the adjacent resistor a little for it to fit).

STEP 7: remove the 820pF capacitor and replace it with a 4.7nF MKT capacitor (do not make this change if you will be driving the amplifier from a high source impedance, ie, more than 220Ω).

STEP 8: remove the inductor and wind a new one with 30.5 turns (rather than 25.5 turns) of 1mm-diameter enamelled copper wire. We published detailed instructions on how to do this in last month's Ultra-LD Mk.3 construction article. It must be wound and installed with the correct orientation, as shown on the overlay. You can re-use the inductor bobbin if desired.

STEP 9: remove the 150nF 400V capacitor and replace it with a 220nF metal film capacitor (250/400V DC or 250V AC).

Re-attaching the board

When all those changes are complete, re-attach the board to the heatsink. This is best done by re-inserting the machine screws through the tabs, hanging the insulating washers off them and then screwing each transistor to the heatsink with a couple of turns before tightening them all up.

Make sure that the silicone insulat-

Parts List

1 PCB, code 01209111, 20.5 x 36.5mm
1 1kΩ 25-turn vertical trimpot (VR1)
1 10μH air-cored inductor (or 1 pot core bobbin and 2m of 1mm diameter enamelled copper wire plus a short length of 20mm diameter heatshrink tubing)
2 6.3A, 6.5A or 7.5A M205 fast-blow fuses
1 50cm length wire-wraping wire (Kynar) or light duty hookup wire
1 TO-126 or TO-220 insulating washer
1 M3 x 15mm machine screw, M3 flat washer and nut
1 M3 x 10mm machine screw

Semiconductors
1 BD139 1A NPN transistor (Q16)

Capacitors
1 1000μF 16V electrolytic
1 470nF MKT
1 220nF 250/400V DC or 250V AC MKT/MKP
1 4.7nF MKT or ceramic
2 180pF 100V Polypropylene (Rockby stock code 36350)

Resistors

1 2.2kΩ	1 120Ω
1 330Ω	1 68Ω
1 220Ω	

ing washers are all aligned properly before finishing the job.

The upgrade board can then be fitted. Start by soldering its wire "D" to to the pad on the main PCB adjacent to Q11, labelled "D" on the overlay diagram (Fig.3). The upgrade board is then secured to the heatsink, with the component side up and Q16 on the bottom, using an M3 x 10mm machine screw, flat washer and silicone rubber insulating washer (TO-126 or TO-220 size).

If your hole isn't tapped, use a 15mm machine screw and feed a nut between the fins using small pliers.

With the upgrade board firmly attached to the heatsink, re-check the isolation of all transistors. To do this, remove the fuses and set your DMM to Ohms mode. Measure between the face of the heatsink and the nearest fuse clips on either side. If the reading is less than several megohms then one or more of the insulators has been punctured or is improperly installed and must be fixed.

You also need to check that Q16 is properly isolated. To do this, check the resistance between the heatsink and the right-most lead of the the 330Ω resistor (the one closest to Q16). This too should read very high.

You can then set about soldering the six remaining wires from the upgrade board to the appropriate pads on the amplifier PCB. These are labelled with letters A-G on the overlay diagram, corresponding to the pads labelled A-G on the upgrade board. Wires A and B are soldered to vias, which have enough exposed copper for solder adhesion (they are essentially small pads). Wires C, F and G are soldered to now-empty pads.

Wire E is soldered to the bottom-most lead of the 10Ω 1W resistor. Strip that wire back a bit further than the others and wrap it around the resistor lead before soldering it in place.

Alternative upgrade method

It is possible, though not recommended, to install the upgrade board without the need to detach or drill the heatsink. In this case, Q16 is mounted on the tab of Q10 or Q11, using the same screw (an insulating washer is still required). The disadvantage of this approach is that the extra thermal resistance between Q16 and the heatsink means that the thermal tracking is inferior and so the quiescent current is not as well controlled.

If you do decide to take this approach, fit a rectangle of insulating material to the bottom of the upgrade PCB (eg, presspahn or plastic cut from a takeaway container or "blister pack"). This can be held on using cable ties. Otherwise, the bottom of the PCB could short against the top of the 1000μF 63V capacitors.

Testing and adjustment

With all the connections made, the amplifier can be tested and the quiescent current set, as follows:

STEP 1: wind trimpot VR1 (on the upgrade board) fully anti-clockwise. Since this is a 25-turn trimpot it can take many turns before it is at its end-stop. The screw normally continues to turn once the end has been reached but you should hear a soft click with every revolution.

STEP 2: remove the fuses (if installed) and replace them with 68Ω 5W safety resistors. These can be soldered to blown fuses as shown in the Ultra-LD Mk.3 construction article elsewhere in this issue. These then plug straight into the fuse-holders.

STEP 3: wire up the supply leads to the module; be very careful to get these right or damage is likely once power is applied. **These voltages are high enough to be lethal (especially the 110V or so between the positive and negative rails) so you must be careful to avoid touching the wiring and fuseholders while power is applied to the board.** In fact the safest thing to do is to avoid touching the board at all.

STEP 4: connect a DMM set in volts mode across one of the safety resistors. If possible, use alligator clip leads.

STEP 5: apply power and watch the voltage reading. Cut power immediately if you get a reading of more than 10V across the safety resistor. In fact it should be below 1V (but may "dance around" a bit). If the power is left on and there is a fault, the safety resistors can quickly burn out.

STEP 6: slowly wind VR1 clockwise. The voltage across the safety resistor should stabilise and start to rise. Adjust it so that the reading is about 9.5V.

STEP 7: measure the voltage across the speaker output terminals. This should be no more than ±50mV (it's typically around +20mV).

Assuming that's all OK, you can cut the power, wait for the filter capacitors to discharge fully and reinstall the fuses (using the specified 6.5A types, or the closest you can get). The module can then be reinstalled in the chassis. A quick test with a signal source and some speakers should confirm that the upgraded module is working correctly.

Once the amplifier is restored to full working condition, it's a good idea to run it with the lid on for an hour or so with normal program material and then check the voltage across one of the 0.1Ω emitter resistors on each amplifier module. If this is more than about 15mV, wind the associated adjustment trimpot back a little. Although the upgraded module will have improved thermal tracking, its quiescent current can still increase a bit as the module warms up so it's a good idea to re-adjust the setting once it has been operating for a while. **SC**

Vintage Radio

By Maurie Findlay, MIE Aust, VK2PW

Performance improvements for the Hotpoint Bandmaster J35DE console radio

The two previous articles on this set dealt with its restoration. The aim was to make the set work as it did originally. We now look at what can be done to improve the performance in the light of design knowledge some 60 years later.

IF YOU ARE ONE of those who only wish to restore a radio as close as possible to the original, this article is not for you. We can understand those who strive to produce the vintage radio equivalent of the Concours d'Elegance but as we have pointed out in the past when discussing many valve radios, they often had design faults and unfortunate compromises.

OK, what was wrong with the design of the Hotpoint? At the time it was produced it would have been regarded as a great set.

The most serious fault is the attenuation of higher audio frequencies due to the tight selectivity of the intermediate frequency stage. Selectivity refers to the "sharpness" of tuning in a radio. This was common to sets manufactured by big companies and built by hobbyists in the 1940s and 1950s.

The usual practice was to have the IF (intermediate frequency) at 455kHz and one IF valve stage. Tuned transformers, each with two circuits, were used, one between the mixer and the IF amplifier and the other between the IF amplifier and the diode detector.

Radios intended for use in country areas sometimes had two IF amplifier stages and three IF transformers – a total of six circuits tuned to 455kHz.

They were great for picking up distant stations but due to the severe attenuation of the high audio frequencies, they always sounded very "mellow". These days we would simply regard the sound quality as muffled.

In order to appreciate why this happens, we need to look at the nature of the signal transmitted by the radio station.

Say the station is transmitting with a carrier at 1MHz (1000kHz) and it is modulated with a tone of 5kHz. Then, the station is actually transmitting three separate frequencies: 995kHz, 1000kHz and 1005kHz. If you put in a filter which passes the 1000kHz but attenuates the 995kHz and 1005kHz frequencies, they will be reproduced at a lower level.

Spectrum analysers and other sophisticated test instruments were not generally available in design laboratories in the 1940s and 1950s and many engineers were a bit hazy about the idea of sidebands. In the 1960s, single sideband (SSB) transmission became

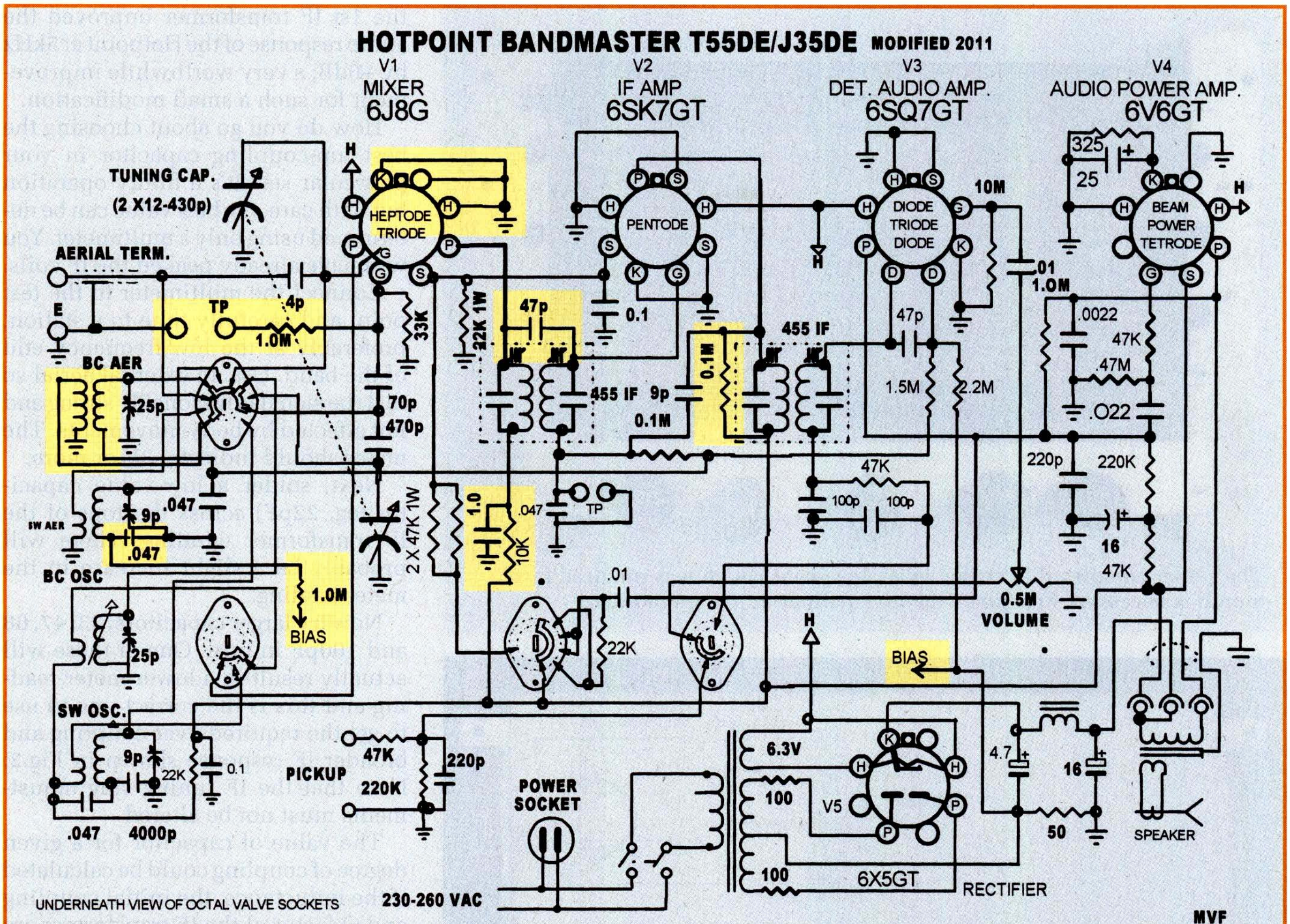


Fig.1: while some vintage radio restorers may regard this as sacrilegious, this diagram shows how the circuit can be modified to improve its performance. Specifically its audio bandwidth can be widened and the gain increased.

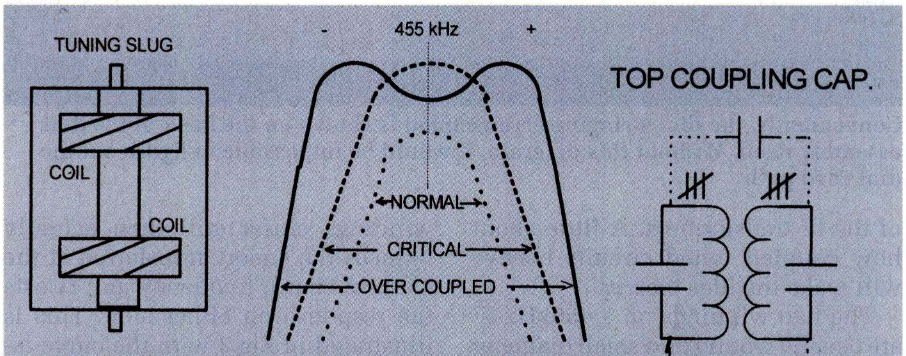


Fig.2: this diagram shows how a top-coupling capacitor across the two coils in an IF transformer can be used to increase the audio bandwidth.

the standard for high-frequency communication circuits and designers began to realise that you could survive with one sideband only. But that's another story.

If people wanted a wider audio response in the early years, the solution was to have a TRF (tuned radio frequency) receiver. Many of these were built by hobbyists from designs in popular magazines. They usually had three tuned circuits and two valve amplifying stages, followed by a detector.

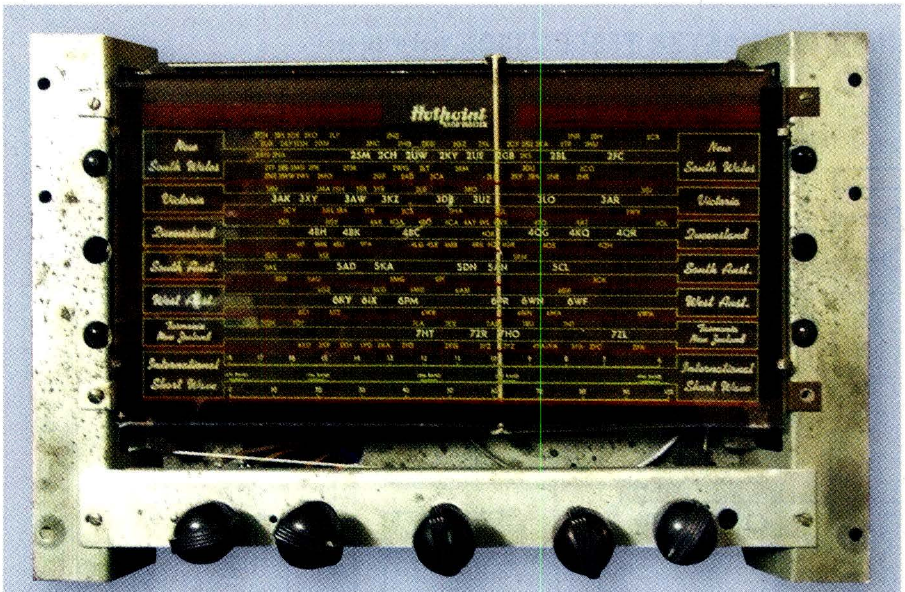
The difficulty was that they were only suitable for areas close to strong stations. And if there were other stations close in frequency to the one you wanted, they would often break through. In other words, they had poor selectivity.

A better solution

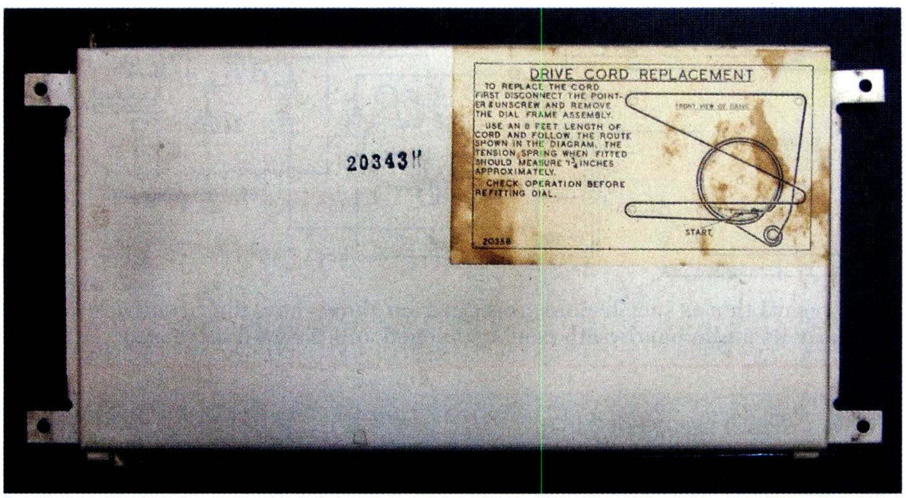
A better solution is to design the 455kHz amplifier so that it will pass the higher frequency sidebands. How high? Currently, in Australia, broadcast stations are separated by 9kHz. The authorities have taken great care in allocating channels, in a geographical sense, so that there is little chance of local interference from adjacent channels. In theory, a filter which had a level response centred on 455kHz and maybe 20kHz wide would be OK.

But how to make such a filter? We would have to get the old engineer's slide rule out and do some sums but such a filter could easily have 16 inductors with precisely defined Q factors. In addition, the losses through the filter would certainly make it necessary to have another amplifying stage – not practical.

How about a compromise? There is a way that the response to higher audio frequencies can be improved. It involves changing the coupling between the windings of at least one



The rather complex dial stringing arrangement which was pictured last month is necessary to support the long pointer at top and bottom.



Conveniently, the dial stringing arrangement is shown on the back of the dial assembly itself. Without this diagram, it would be impossible to figure out the dial cord path.

of the IF transformers. A little about how coupled tuned circuits behave will make the idea clearer.

The two windings on a 455kHz IF are usually wound on a small diameter former and placed in a shielded can one above the other (see Fig.2). They are each tuned by fixed capacitors and a ferrite or iron-core slug which can be moved up and down inside the winding. The windings are carefully placed so that when one is adjusted it does not affect the other. This is called under coupling and is how most IF transformers are arranged.

If the windings are brought closer together, the transfer of energy from the primary to the secondary will increase until a peak is reached. Bringing the windings closer still then actually reduces the energy transferred at the 455kHz centre frequency and boosts the response on either side. This is illustrated in Fig.2 with the curve labelled "Over Coupled" and gives a clue as to how the response can be widened.

Top coupling

It would not be easy to increase the coupling between the windings by moving them in an existing set but the same result can be achieved by connecting a small capacitor between the tops of the windings. The degree of over-coupling depends on the value of the capacitor and we have done some practical work to see what can be done.

A 47pF capacitor connected across the 1st IF transformer improved the audio response of the Hotpoint at 5kHz by +6dB; a very worthwhile improvement for such a small modification.

How do you go about choosing the best top-coupling capacitor in your particular set? It's a fiddly operation but with care, the best value can be determined using only a multimeter. You will have already peaked the IF coils.

Connect the multimeter to the test point and carefully tune to a station, preferably at the low-frequency end of the band. Use an external aerial so that the signal is reasonably strong and not affected by body movements. The meter should indicate -3V or more.

Next, solder a low-value capacitor (eg, 22pF) across the tops of the IF transformer winding. There will probably be a slight increase in the meter reading.

Now try larger capacitors: 33, 47, 68 and 100pF in turn. One of these will actually result in a lower meter reading and this is the correct one to use to get the required over-coupling and broader IF response shown in Fig.2. Note that the IF tuning slug adjustments must not be altered

The value of capacitor for a given degree of coupling could be calculated if the inductance, the initial coupling and Q factor of the IF transformer are known but it is much easier to determine by experiment.

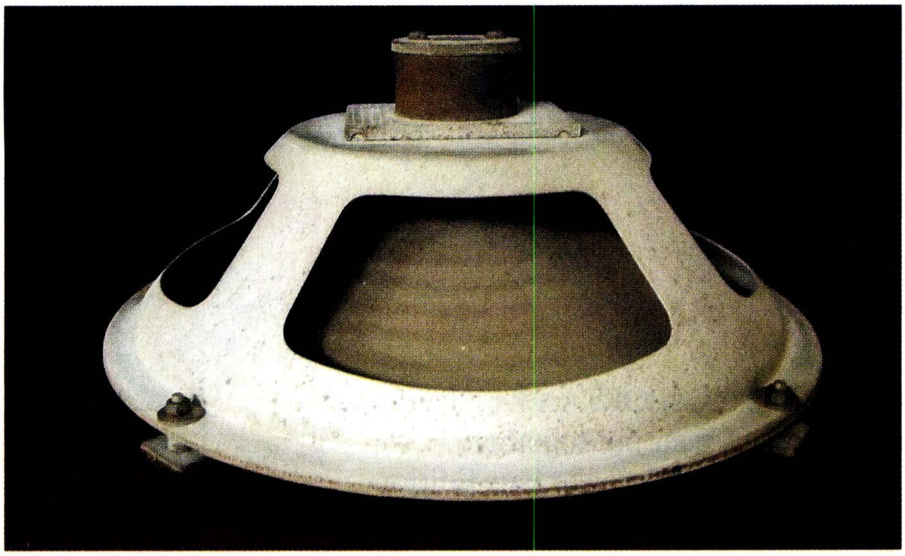
HT modification

A slight complication now arises: the hum on the high-tension (HT) line is now applied to the grid of the IF amplifier and the AGC-detector lines via the top coupling capacitor. This makes it necessary to put in a resistor/capacitor filter to feed the high-tension to the plate of the mixer valve.

The primary winding of the second IF transformer will usually have a high Q which will fill in the dip in the response of the over-coupled first IF but in our case it also contributed to the sideband attenuation. A 0.1MΩ resistor wired across the primary gave the optimum overall IF response.

The improvement is well worthwhile and the resulting overall frequency response of the set is about -3dB down at 5kHz instead of the original -10dB (if you want the original "mellow" tone, the function switch is still available).

The modification makes it easier to understand speech and enjoy music.



One curiosity of the Hotpoint J36DE set is that the loudspeaker is installed with 10mm spacers between its frame and the baffle. We're not sure why this is so but suspect that it was done to reduce the bass response because the set does have audible hum. Alternatively, the designers may have been concerned about acoustic feedback. As a consequence of this odd installation method, the entire speaker cone had come away from the speaker frame and had to be glued back in place.

However, it certainly does not make the set comparable with modern FM or digital receivers in terms of distortion or frequency response.

Modifying the converter

Another quirk of the original design of the Hotpoint is the operating condition for the 6J8G frequency converter. The negative bias applied to the signal grid is that supplied by the back-bias resistor, through the AGC network, plus that developed across the 200Ω resistor at the cathode. It is too high. As a result, the gain available for weak signals is less than the valve can provide.

The solution is to earth the cathode of the 6J8G. This provides maximum gain from the converter and better operation of the oscillator, particularly on shortwave reception.

With the cathode of the 6J8G earthed, it is necessary to return the shortwave aerial coil to the back bias network. The added components are a 1MΩ resistor and .047μF (47nF) capacitor. This retains the original idea of no AGC on the converter on shortwave.

The overall gain of the set with the modifications shown on the circuit is actually slightly more than with the original design. The increased mixer gain and that attributable to the closer 1st IF coupling more than makes up for the losses due to the damping of the 2nd IF.

Even with the increased gain, the Hotpoint needs a reasonable length of internal or external aerial wire for good daytime reception of local stations. All glass miniature valves which became available a few years later had much higher gain. In combination with efficient ferrite rod aerials, they made external aerials unnecessary for the medium-wave band.

The original design also has a series 455kHz tuned circuit across the primary of the broadcast aerial coil. It was intended to reduce interference from airport navigational beacons. Unfortunately, it also reduces the sensitivity of the radio, particularly at the low-frequency end of the band and when a short aerial is used.

Beacons of all sort are now kept away from 455kHz so this filter is no longer necessary. It can be disabled by removing the associated 50pF capacitor.

The set works better when modified as described. It would be interesting to talk to the set's original engineer but he or she has now probably passed on to a higher design laboratory.

Increasing the audio power

Finally, the conservative operating conditions for the 6V6GT output valve are worthy of comment. A 325Ω cathode bias resistor is used with about 250V applied to both plate and screen. The optimum load for these conditions is about 7000Ω and the undistorted power output around 1W at the speaker transformer secondary (the original specification says 3W!).

Slightly more audio power can be obtained by reducing the cathode bias resistor to 250Ω and the plate load to 5000Ω but at the expense of more heat and shorter valve life. Speakers used with sets of the period were quite sensitive and 1W is enough for most situations. SC

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ASK SILICON CHIP

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Parts for 1000:1 prescaler

I have a question about your article on the 1000:1 UHF Prescaler For Frequency Counters (SILICON CHIP, October 2006), which was reprinted in the January 2009 issue of *Everyday Practical Electronics*.

I can't seem to find the panel switch for power (DPDT toggle, right-angle PC board solder mount with threaded bushing). I've seen this kind of switch before but cannot lay my hands on one that matches (4mm lead spacing, etc).

I wonder if you can give me an example of a manufacturer and part number for this switch. I can't wait to actually assemble this project but I have a strong desire to pre-fit the parts to make sure I have drilled everything right, before I assemble the board!

I need similar advice on sources and part numbers for the SMA connector, though I can probably adapt the board to a different part if need be. (P. S., Washington, DC).

• The mini DPDT PCB-mount switch used in the UHF prescaler is the one still stocked by Australian retail chain Jaycar under their catalog number ST-0365. It is available from them direct via their website at **www.jaycar.com.au**

The reverse PCB-mounting SMA socket used in the same project is also stocked by Jaycar, catalog number PS-0596. This can also be ordered direct from the Jaycar website.

24V version of Digital Lighting Controller

Your Digital Lighting Controller (SILICON CHIP, October & November 2010) is designed for 240VAC operation. What changes would be required to operate the Triacs on 24VAC, as most Christmas lights operate on 24V not 230V. (J. S., Rockingham, Qld).

• We have not tried it but the slave module should be able to switch 24VAC for LEDs. There are some minor disadvantages of doing it this way though.

First, for the same amount of lighting power, the unit will need to switch roughly 10 times as much current. For LEDs, this will probably be OK as LED strings usually don't require a lot of current. Keep in mind though that the total current for all the LEDs will be flowing through the power input connector.

Another disadvantage is that the voltage loss across each Triac is a more significant proportion of the total. This reduces the overall efficiency.

Practically speaking though, we don't think either of these problems will prevent you from using the slave module to control 24VAC. You will just need to use different connectors at both ends.

We don't think the Triac latching current will be an issue but if it is, you can set the master module to drive the Triacs for the full conduction period (this was explained in the article published in November 2010).

Having said all that, we intend publishing a new slave module design to suit LEDs running off 12VDC or 24VDC. This will use Mosfets and will be significantly more efficient for low voltage control than Triacs controlling 24VAC. The project is scheduled for next month (October).

Valve guitar preamplifier

I have built the valve preamplifier featured in the November 2003 issue and I would like to modify it to use as a guitar and mike preamp with a volume control. Could you please advise me on the necessary modifications? (P. C. via email).

• Very few modifications are required for your application. If you want a volume control, this can be fitted in place of the 1MΩ output bleed resistor, with the pot wiper connecting to the output connector.

Using The Railpower With Lower-Voltage Motors

I refer to the Railpower Train Controller project described in the September & October 2008 issues of SILICON CHIP. I would like to use it for experiments with 6V or 12V DC motors (instead of 17V). Can you advise whether I can change some components to obtain a 12V DC output?

If I installed a 6V to 15V 2A multi-tapped transformer, would there be only minor changes to obtain 6V DC output? (N. S., via email).

• The Railpower Train Controller is a pulse power circuit where the voltage applied to the motor comprises narrow 17V pulses. Even at full speed the pulses have a duty cycle of only about 71%. This gives an average of 12V.

So while the peak voltage delivered to the motor is 17V, the average voltage delivered to the motor is actually 12V, suitable for running 12V motors in model railway locomotives (typically HO and OO or larger scales). Or you could use in on N-gauge layouts which typically use 9V motors. It is just a simple set-up adjustment. There is no problem with running DC motors with pulse power.

If you wanted to use a multi-tapped transformer it could be used to provide less than 17V for the main supply rail. For example, you could connect it to provide somewhere between 9-12V DC and then the unit would operate to provide pulsed DC to a 6V motor. Once again,- it is merely a matter of a simple set-up adjustment.

Note that if your volume control has a lower resistance than 1MΩ, the value of the output coupling capacitor will need to be increased in order to maintain the bass response. For example, if you use a 500kΩ pot, you should ideally connect a second 220nF 630V capacitor in parallel with the existing capacitor.

If you want to increase the preamp gain a little, change one of the 33kΩ feedback resistors to 47kΩ or 68kΩ. Note that doing this will inevitably reduce the frequency response and also increase the noise and distortion to some extent.

Multi-channel mixer wanted

I am enquiring as to whether you have ever published a project to build a stereo audio mixer. I'm looking for a unit that I can use at home and occasionally take out to parties, with inputs for say two laptops, two microphones and two auxiliary sources.

My basic requirements include the following: 6-channel stereo; two balanced/unbalanced mic inputs; four unbalanced laptop/MP3/aux inputs with bass, mid and treble controls and possibly master tone controls; a headphone output; and an amplifier output (possibly balanced).

If you haven't done one already, would you consider such a machine as a future project? I'd be quite sure that there would be a demand for such a thing. My children love playing around with music at home and one of these would be really useful. (P. W., Auckland, NZ).

• Our last stereo mixer project was in November & December 1996 and had eight input channels mixing down to two. It was very comprehensive but not cheap. While all the parts would still be available, you would have to make your own metalwork.

Upgrading the 20A speed controller

The 12/24VDC 20A Motor Speed Controller described in the June 2011 issue is great. Is there a way I can upgrade this kit to 40A? I do not mind making the unit box bigger or can I just upgrade the Mosfets? (J. N., via email).

• The circuit as designed is rated for up to 20A. To upgrade it to 40A, you would require wider PC tracks for the current carrying conductors and a 40A diode (eg, a 1N6097 50A diode). The fuseholder would also have to be changed to suit 40A fuses.

The two Mosfets should be suitable for 40A but may require better heatsinking or you can add more in parallel, along with extra gate resistors.

In short, the whole PCB would need to be re-designed to do the job properly.

Wants 24V Version Of Ultrasonic Cleaner

I need some information regarding the primary wire on the output transformer of the Ultrasonic Cleaner as published in the August 2010. The wire specified for the primary seems to be very rare indeed. It is specified as 14 x 0.20mm figure-8 wire.

In the US, it seems that we call this zip cord. I can find no supplier for this wire. Our biggest supplier, Digikey, shows various configurations but the closest is 7 strands x 30 gauge = 0.254mm.

In light of the fact that I need to run the cleaner on 24V, you have previously advised that the number of turns on the primary must double. The current should then be one half of its previous value. Could I then use thinner wire such as 7 x 32 gauge = 0.203mm?

This all comes as a result of my uncertainty as to the reason for the very strict multi-strand 14 x 20 requirement. Does it act as Litz high-frequency wire? Or is it just to get a flexible high-current wire?

In order to run on 24V, can the secondary of the output transformer be reduced to 45 turns instead of doubling the number of turns on the primary? This would eliminate the potential problem of not having enough space on the bobbin. If I need more space on the bobbin to accommodate more turns on the primary, can a bigger bobbin be used without affecting the effectiveness of the cleaner? (J. B., via email).

• The wire gauge is not critical and so 7 x 32 gauge wire would be suitable, especially for 24V operation. The wire was specified as a metric size and is commonly available in Australia. USA wire is possibly different with imperial sizes. Figure-8 wire was specified because that provided a ready made bifilar winding that was insulated from the secondary.

For 24V operation, you need to double the primary winding turns rather than reduce the secondary turns, otherwise the transformer would saturate towards the end of the drive period, causing the Mosfets to drive what would effectively be a short circuit. A larger former could be used.

You also need to replace the 4700µF 16V capacitor with a 35V type and replace the 100µF 16V capacitor on the 78L05 regulator's input with a 35V type. In addition, the power and running LED resistors should be increased to 10kΩ.

We have not tested these circuit changes.

Speed controller causes servo hunting

I am using your 12V Speed Controller (SILICON CHIP, November 2008) to control a cordless drill motor in a gauge-1 model train which is also radio-controlled. However, the unit interferes with the R/C servos; they are hunting.

Do you know of a cure for this problem? I have not yet tried changing the 220nF timing capacitor at pins 2 & 6 of the 7555 as a possible cure for the motor whine. (K. K., via email).

• The speed controller and motor are possibly producing radio frequency interference and causing the remote control to be affected. This interference is due to the rapid switching transitions of the pulsed waveform that's applied to the motor.

A small 100pF capacitor across the train motor may shunt sufficient RF to prevent the interference. Added inductance of 100µH may also be required between the speed controller's output and the motor. Suitable 5A 100µH chokes are available from Altronics and Jaycar. With the added inductor, the shunt capacitor can be increased to 100nF and connected across the rail track supply.

Motor whine may be reduced by changing the value of the 220nF capacitor and this can be anywhere in the

Using The Jupiter Receiver As An RF Preamp

I am looking for an RF preamplifier to improve the sensitivity on a couple of old communication receivers. I came across your Planet Jupiter Receiver in the August 2008 issue and would like to know if the RF preamp for this unit could be used for my purpose (ie, the section of the circuit before it connects to IC1)?

I believe the Q of the circuit needs to be changed. What other values need to be altered to make it suitable for the 1.5-25MHz range? (P. T., via email).

• The Planet Jupiter Receiver's RF stage probably would be suitable as a preamp for use with HF communications receivers but with some modifications. We would not suggest that you try to make the amplifier broadband by reducing the Q of L1, because the amplifier's performance would be degraded too much.

Instead, we suggest that you switch L1 and VC1 for three bands, say, 1.5-4.0MHz, 4.0-8.0MHz and 8.0-25MHz. As a starting place for the three L1 coils, use 90 turns for the lowest band, 60 turns for the middle band and 30 turns for the highest band. That done, remove the fixed capacitor across VC1 and just switch in a 6-30pF trimmer for each band or as an alternative, use a 10-120pF miniature tuning capacitor connected permanently across the tuned circuit, to allow you to manually tune for a peak on any of the three bands.

This would be much better than trying to set trimmers for the best compromise on each band.

The aerial input tap for each coil should be at about 20% of the turns up from the ground end, ie, at about 18 turns for a 90-turn coil, 12 turns for a 60-turn coil and six turns for a 30-turn coil.

Do not attempt to tune the output of the amplifier, as this will invite instability. Instead, leave RFC1 and the series 100Ω resistor as the untuned load for Q1 and use a 2.2nF capacitor to couple the output to the aerial terminal of your communications receiver.

range from 47-470nF. You will need to experiment to find the best value.

Headlight reminder project has smoke

I recently built the Headlight Reminder For Cars (Silicon Chip, August 2001). After installing all the components and the two links for testing, I connected 12V and found that the 10Ω resistor located at the top left corner of the PCB started to smoke (this resistor is in series with the +12V supply).

I switched off immediately and rechecked all of the connections and then rechecked the links before reconnecting the power. This gave me the same result – a smoking resistor. I am not sure if I am doing something wrong. Your help would be appreciated. (J. S., via email).

• The 10Ω resistor will overheat if there is a short circuit on the supply. Make sure there are no solder bridges between the pads of the ICs and between the LK1/LK2 pads and the LK3/LK4 pads. Compare the PCB solder connections against the published PCB pattern to see if there are any of these bridges present. Sometimes, a hairline bridge can form between pads.

Make sure all ICs are located correctly and orientated correctly. Finally, check that the electrolytic capacitors are installed with the correct polarity.

Using a narrow-band oxygen sensor

I have a query about the Wideband Air/Fuel Mixture Display unit. I know that I can use a narrow-band oxygen sensor with this display. However, if I want to use a wideband sensor do I have to also use the Wideband Controller Unit?

Please note that I do not want to change any values in the ECU. All I want to do is monitor the air-fuel ratio in day-to-day driving.

In summary, if I want to monitor air-fuel ratio using a wideband sensor and not to change any variable in the ECU do I use only the Wideband Air-fuel Mixture Display Unit? And if I want to monitor the air-fuel ratio using a wideband sensor and change variables in the ECU, do I use the Wideband Air-fuel Mixture Display Unit and the Wideband Controller unit? (D. R., via email).

• The Wideband Air-Fuel Mixture Display (Silicon Chip, November 2008) can be used to measure the signal from a narrowband oxygen sensor without affecting engine operation. If you want to use a wideband sensor, this must be used with the Wideband Controller (Silicon Chip, September & October 2009) and the display can then be used to show the wideband readings from the controller.

When using a wideband sensor in a car designed for a narrowband sensor, then the narrowband sensor can be replaced by the wideband sensor but it must be used with a wideband controller. In use, the wideband controller provides a simulated narrowband signal that can be connected to the ECU to provide for normal engine operation.

The wideband display connects to the wideband output of the wideband controller to display the mixture reading.

Milliohm adaptor adjustment problems

I built the Milliohm Adaptor for DMMs, as described in the February 2010 issue and set up the unit using a 10Ω 1% tolerance resistor, as described in the article.

Switching to the 1Ω range, the output voltage is 1.00V with a 1Ω 1% resistor – a good result. However, when a 0.1Ω 1% resistor is connected, a reading corresponding to 0.076Ω is measured with the sense connections directly across the resistor body.

Including the connection pigtails increases this to 0.085Ω. A second resistor gave similar results.

Setting aside the issue of the correct measuring points for making the measurement, the results seem consistently low at this lower limit. Is this to be expected? (T. W., Auckland, NZ).

• Consistently low readings are not to be expected at the lower end of the 0-1Ω range of the Milliohm Adaptor. It should be possible to correct this error by doing one of two things:

(1) Adjust trimpot VR3 very slightly, so the force current on the 0-1Ω range is slightly higher than 10.00mA.

(2) Adjust trimpot VR4 very slightly, so that the amplifier's gain is slightly higher than where you set it during the calibration procedure.

Either of these options should be

Next Month In SILICON CHIP: October 2011

CadSoft EAGLE PCB Design Software

Have you been wedded to Protel Easytrax or Autotrax as your favourite CAD PAC software? But hey, it's so last century; DOS and all that. Now there is an affordable alternative which runs on Windows, Mac OSX and Linux. We will have a comprehensive review, including the free version for non-commercial use. (Note: this review was held over from this issue, due to space constraints).

Measuring Audio Performance With A USB Interface And Your PC's Sound Card

Measuring audio performance is now much easier because all you need is a reasonably up-to-date PC with a decent sound card or a USB sound interface, plus an audio analyser software package. In this article, we describe the basic concepts, using a package called "TrueRTA".

LED Slave Unit For Digital Lighting Controller

Our Digital Lighting Controller can now control LED strings with this new DC slave unit. Up to eight LED strings can be individually controlled. Build it now and have it running for the best Christmas light display in your street.

Deluxe Quiz Game

Are you impressed by the electronics in TV quiz games such as *QI* and *Talkin' About Your Generation*? Now you can have the same great sound effects as on those shows. Fancy a fog-horn, a burst of music from your favourite composer or just some way-out ring tone? Now you can have it with our new quiz game. It uses an SD card, an MP3 playback module and you guessed it, a microcontroller.

Olde-Worlde Geiger Counter

The project is based on a genuine ex-armed forces Geiger counter which was actually intended to be used to check battlefields in the aftermath of a nuclear event (big bang). Now it has been updated with semiconductors to make it work with much lower (safer!) levels of radiation. Thinking of a tourist trip to Fukushima? Build yours now and be prepared!

quite easy to do but the VR3 adjustment is preferable because that will have no effect on readings on the 0-10Ω range.

Dud tantalum capacitor causes micro to reboot

I built the Digital Lighting Controller master module (SILICON CHIP November-December 2010) from an Altronics kit.

When I apply power, the green LED flickers rapidly but nothing else happens. I checked that the microcontroller is correctly programmed (using a PICkit 3 with an adaptor board) and it is. The output of the 3.3V regulator powering the micro is spot on.

It does the same thing regardless of whether or not I plug in a memory card. I checked that all the components are in the correct locations (and correctly orientated) and all the solder joints look good. What could cause this? (M. D., Perth, WA).

• This points to a problem with the 10μF tantalum capacitor. The microcontroller has an internal 2.5V low-dropout regulator that it uses to power its core from the 3.3V supply. The tantalum capacitor's performance is critical since, if it does not filter the supply properly, as soon as the microcontroller switches to a high-speed clock the microcontroller is likely to "reboot".

The micro starts off running from its internal RC oscillator at about 3.7MHz and then the software sets up the PLL (phase locked loop) so that it can run faster. As soon as the new clock is set up, it turns on the LED.

It is likely that it is rebooting shortly after the clock speed goes up, due to a dud tantalum capacitor (either low in capacitance or high in ESR) failing to smooth the core supply voltage at this higher clock speed.

Keypad for a shed alarm

I am constructing the excellent Solar-Powered Shed Alarm of March 2010 and would like to ask for a little help as well. The main on/off switch is vulnerable to a burglar, eg, should the hidden location of the UB3 utility box be inadvertently disclosed by the owner.

I would like to increase the security one notch by replacing the keyswitch with a simple coded keypad placed carefully in the full detection zone of the PIR. Then, "micro switching" the keypad enclosure, the PIR and the siren enclosure box to Input2 or Input3, configured to instant response, would appear to be a noisy and effective deterrent to tampering.

I would really prefer to use a simple coded keypad as I have enough individual "dongles" on my keyring for other applications – garage door opener, household alarm, etc.

I cannot find a suitable keypad circuit I could adapt to replace the on/off switch in this application. Would you be able to help with a simple keypad interface circuit to replace the key lock please? Also, while I am not familiar with PIC programming, would a pre-programmed PIC suit the application? (C. O., via email).

• We published a suitable keypad alarm in the April 2003 issue. We can supply that issue for $12.00 including postage within Australia.

Micro strip-line explained

I am currently building the Radar Speed Gun (SILICON CHIP, November & December 2006).

One of my reasons for building the kit was I have no experience with this part of the RF spectrum. In the description of the microwave head circuit you state the following: "with the oscillation frequency determined

Changing The Tone Controls In The Guitar Preamplifier

I am planning to build the 2-Channel Guitar Preamplifier that was featured in the November 2000 issue of SILICON CHIP. However, it's been mentioned to me that the tone control frequencies are not suited for guitars, especially the mid control set at 1kHz. It seems that the mid-frequency tone control should be centred closer to 500Hz and the treble control shifted down to between 3kHz and 5kHz.

As well, the bass control should be centred on 100Hz rather than around 50Hz. Could you please advise how I can change this when I build the preamp?

● The bass control 15nF (.015µF) capacitor can be halved in value to 6.8nF to shift it to 100Hz. The mid tone control capacitors can be doubled in value from 2.7nF (.0027µF) and 12nF (.012µF) to 5.6nF and 22nF respectively for a 500Hz centre frequency. Similarly, the 1.5nF (.0015µF) capacitor for the treble can be increased to 3.3nF to set the boost/cut to 4.5kHz. Alternatively, a 3.9nF value should set the frequency to 3.8kHz.

by the microstrip line connected to the collector".

I would be most grateful if you could either enlighten me as to this part of the design process or advise me as to where I could further educate myself in relation to microstrips and their utilisation. (T. G., Banstead, UK).

● In general terms, a microstrip line terminated in a short circuit at one end acts very much like a transmission line "tuned quarter-wave stub" or a parallel tuned circuit. The frequency of resonance is inversely proportional to the effective electrical length.

You can find a lot more about microstrip lines in recent editions of the *RSGB Radio Communications Handbook* or in *Practical Microstrip Design and Applications*, by Gunter Kompa. Artech House, 2005. (ISBN 1-58053-980-7).

How to test an electric fence

I want to monitor my electric fence which runs between 6-16kV (depending on installation and equipment). All I need is a flashing LED in unison with a HV pulse to show the fence is live.

I would like to incorporate the flashing LED into signage appearing every few metres along the fence to warn the public. The easiest and cheapest circuit would be appreciated or any other thoughts. (K. D., via email).

● We published three electric fence testers in an article in May 1999. One of these incorporated a flashing Xenon tube to show that the fence is active. This was powered directly from the electric fence. It stores up energy from the electric fence pulses into a capacitor and when there is sufficient voltage, the Xenon tube fires. Flash rate is proportional to electric fence power.

Upgraded home-theatre speakers wanted

I have a pair of Chinese-made Dick Smith speakers that I bought shortly after you showcased them in January 2006. I use them for left and right speakers in my home theatre set up (film projectors from an old cinema and Dolby surround system, with separate amplifiers for each channel).

They work well but I have seen the JV60 kits that Jaycar are offering and wondered how they would compare to the ones I already have.

Voice clarity is high on my list of requirements. Can you give me some advice also on what I could fit to the Dick Smith cabinets to improve them, such as fitting Vifa midrange speakers? Would I need to change crossovers to do that?

I also use a similar single speaker laid on its side as a centre speaker and I have shortened the cabinet. I have considered buying a Krix vortex centre speaker at around $1000. Are there any options that would give me similar sound at lower cost? (S. C., Kariong, NSW).

● Those Chinese speakers were extremely good value for the money at the time but it is doubtful whether there would be much point in trying to upgrade one particular driver. You would be far better off building a completely new system, bearing in mind that it will cost a lot more money.

By all means have a listen to a pair of JV60s if you can (take along some of your favourite CDs). Failing that, have listen to some speakers in your local hifi store. You might be pleasantly surprised at the cost of commercial systems. SC

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GREAT PRICES
The way it should be!

DIGITAL INDICATORS
- Manual power On/Off
- Zero setting at any position
- Metric/Imperial system conversion at any position
- Max speed 1.5m/sec

RANGE	RESOLUTION		
0-12.7mm	0.01mm	$109	(Q220)
0-50mm	0.01mm	$250	(Q221)

DIGITAL TEST INDICATOR
- Manual power On/Off, Zero, Tolerance & Metric/Imperial buttons
- Zero setting at any position
- Metric/Imperial system conversion at any position
- 0.003mm accuracy

RANGE
±0.5mm/±0.02"

RESOLUTION
0.001mm/0.0001"

$180 (Q2191)

INTERFACE RS-232

DIAL CALIPERS
- Precision dial calipers
- Clear graduations on the dial & beam
- Easy zero adjustment of the dial

RANGE	GRAD.		
0-6"	0.001"	$89	(Q190)
0-150mm	0.02mm	$89	(Q191)
0-200mm	0.02mm	$129	(Q192)

DIGITAL CALIPERS
(IP-54 SPLASH PROOF)
- Auto on and memory hold, accuracy DIN862
- Large LCD On/Off, metric/imperial
- 0.01mm / 0.0005" graduations

IP54

150mm/6"	$89	(Q1751)
200mm/8"	$115	(Q1761)
300mm/12"	$169	(Q1771)

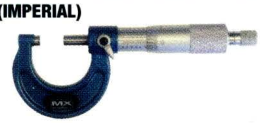
VERNIER DEPTH GAUGE
WITH HOOK
- 0-300mm range
- ±0.05mm accuracy
- 0.05mm graduations
- Clear laser engrave graduations

$99 (Q236)

OUTSIDE MICROMETERS
(METRIC)

RANGE		
0-25mm	$39	(Q102)
25-50mm	$50	(Q105)
50-75mm	$60	(Q107)
75-100mm	$70	(Q110)

OUTSIDE MICROMETERS
(IMPERIAL)

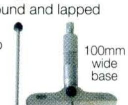


RANGE		
0-1"	$41	(Q101)
1-2"	$50	(Q103)
2-3"	$60	(Q106)
3-4"	$70	(Q109)

DIGITAL MICROMETERS
IP54 (SPLASH PROOF)
- Resolution: 0.001mm/0.0005"
- Metric-imperial conversion, zero setting keys

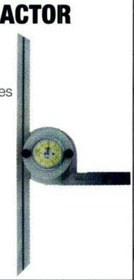
RANGE	ACCURACY		
0-25mm/0-1"	±0.002mm	$169	(Q125)
25-50mm/1-2"	±0.002mm	$175	(Q126)
50-75mm/2-3"	±0.003mm	$189	(Q127)
75-100mm/3-4"	±0.003mm	$239	(Q128)

DEPTH MICROMETERS
- High accuracy interchangeable rods
- Base is hardened, ground and lapped for accuracy
- Positive locking clamp
- Resolution: Metric 0.01mm, Imperial 0.001"



RANGE	ACCURACY		
0-50mm	±0.004mm	$115	(Q145)
0-100mm	±0.005mm	$156	(Q146)
0-2"	±0.00016"	$115	(Q1455)
0-4"	±0.00020"	$156	(Q1465)

BEVEL PROTRACTOR
- Precision bevel protractor
- Suitable for the measurement of angles on jigs, machined components and toolmakers moulds
- Round dial face
- 360° micro fine adjustment

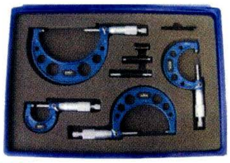


$105 (Q2015)

OUTSIDE MICROMETER SET
- 4 piece
- 0-100mm range
- 0.01mm accuracy

$149 (Q114)

OUTSIDE MICROMETER SET
- 4 piece
- 0-4" range
- 0.0001" accuracy



$149 (Q116)

HEX KEY SETS
- Flip open design
- Extra long ball end hex keys
- Ball head design allows turning of hard to reach fasteners
- 9 piece

IMPERIAL 1/16"-3/8"
$18 (H800)

METRIC 1.5-10mm
$18 (H801)

ENGINEERS SQUARES
GRADE B
- Hardened and polished spring steel blades
- True right angle inside and outside

75mm	$27	(Q644)
100mm	$35	(Q645)
150mm	$39	(Q646)
255mm	$60	(Q647)

SCRIBERS
- Straight and 90° tips with knurled body
- Diamond knurled for comfortable & secure grip


DOUBLE ENDED
$9 (Q630)

PEN TYPE
$19 (Q631)

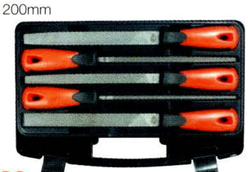
THREAD GAUGE
- Metric and imperial threads
- Enclosed in protective case
- 28 Whitworth (4-62 tpi)
- 24 Metric (0.25-6 pitch)

$14 (Q610)

DRILL SHARPENER
- EDBD-13 economy
- 80 Watts, 240V, 4200rpm
- 3-13mm capacity
- Split point capable
- 118° angle

$109 (D070)

SECOND CUT FILE SET
- Cushion grip handles
- Flat, round, 1/2 round, square & triangular
- 5 piece
- 200mm



$29 (F100)

WORK LIGHTS
- 22 watt - with magnifier
- Fluorescent light
- Long arm model with electronic ballast in the arm

$145 (L282)

240V

- 36 watt
- Long arm with fluorescent light
- Lighting head swivels 310° combined with 210° tilting

$160 (L2825)

WORK LIGHTS
35 Watt - Magnetic base flexible arm

$119 (L283)

240V

55 Watt - Halogen 3 pivot arm 800mm long

$129 (L285)

DEBURRING TOOL
- Includes 10 HSS blades
- Ergonomically designed
- Has thumb rest
- Grips well in hand
- Telescopic holder
- Blades can be stored from the back side

$28 (D060)

SPARE BLADES
- D0605 suits (D060)
- D0615 suits (D061)

BLADES SUIT
D060 $20 (D0605)

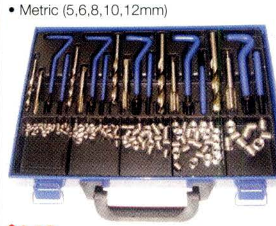
DEBURRING TOOL
SHEET METAL BURR
- Sheet metal burr, hand guard & 2 x Ø11.7mm blades
- Simultaneously removes burrs from both sides of sheet metal
- Range 0-7.5mm

$25 (D063)

INDUSTRIAL STEP DRILLS
- Suitable for sheet metal
- Industrial quality
- HSS M2 bright finsih
- Sizes: 4-12 x 1mm, 6-20 x 2mm, 6-30 x 2mm

$70 (D1071)

THREAD REPAIR KIT
- Metric (5,6,8,10,12mm)



$149 (T100)

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Melbourne: Dandenong Ph: (03) 9212 4422 **Perth:** Belmont Ph: (08) 9373 9999

Specifications & Prices are subject to change without notification. All prices include G.S.T. and valid until 25-10-11

7_SC_310811